

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-252 842

DEVELOPMENT OF A CASE STUDY OF THE TOTAL EFFECT OF
PESTICIDES IN THE ENVIRONMENT, NON-IRRIGATED

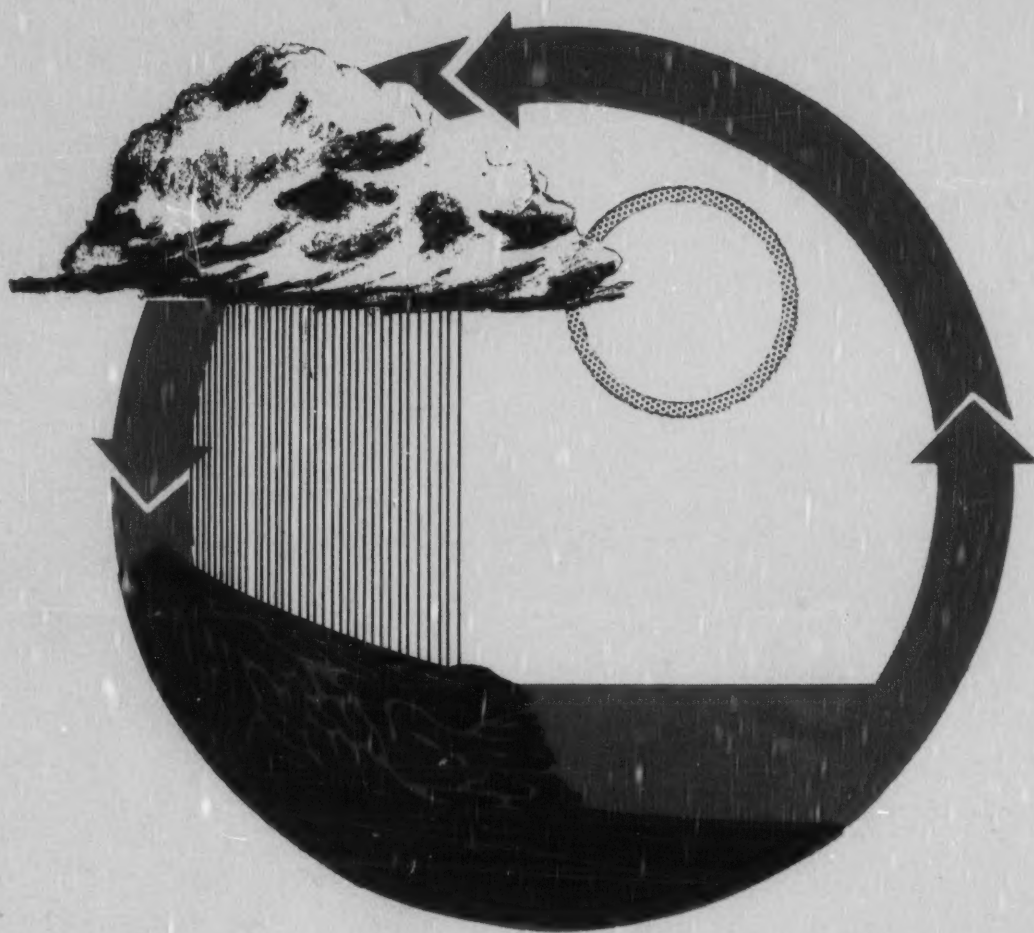
RYCKMAN, EDGERLEY, TOMLINSON
AND ASSOCIATES, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

JUNE 1972



**ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAMS**



PESTICIDE USE ON THE NON-IRRIGATED CROPLANDS OF THE MIDWEST

REPRODUCED BY
**NATIONAL TECHNICAL
INFORMATION SERVICE**
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle Pesticide Use On The Non-irrigated Croplands Of The Midwest		5. Report Date June 1972	
7. Author(s)		6.	
9. Performing Organization Name and Address Ryckman, Edgerley, Tomlinson and Associates, Inc.		8. Performing Organization Rept. No.	
		10. Project/Task/Work Unit No.	
		11. Contract/Grant No. 68-01-0117	
12. Sponsoring Organization Name and Address Environmental Protection Agency, Office of Water Programs, Applied Technology Division, Washington, D.C. 20460		13. Type of Report & Period Covered	
		14.	
15. Supplementary Notes			
Reproduced from best available copy. 			
16. Abstracts			
This study is concerned with pesticide use on nonirrigated cropland, such as those in the midwestern United States. Pesticides are used in this area extensively for weed and insect control. In such lands, most of the area is subject to run-off and erosion which is seasonal. Generally, the pesticides used in this region attach themselves to organic matter and soil particles which, in turn, are carried off into rivers and streams by erosion. Thus, this region exhibits characteristic problems in pesticide application techniques and run-off losses. Using all available information, this study provides an in-depth evaluation of the impact on the natural environment of pesticides used for control of specific pests in the midwestern states of Illinois, Iowa, Kansas, Minnesota, and Missouri.			
17. Key Words and Document Analysis. 17a. Descriptors			
pesticide uses application techniques route of pesticides into water environment impact on the aquatic environment degradation of pesticides in the environment alternatives to chemical control of weeds and insects regulations and laws state laws Illinois Iowa Kansas Minnesota Missouri			
17b. Identifiers/Open-Ended Terms			
17c. COSATI Field/Group			
18. Availability Statement		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 526
i.		20. Security Class (This Page) UNCLASSIFIED	22. Price 13.00-2.25

PRICES SUBJECT TO CHANGE

PESTICIDE STUDY SERIES - 4

DEVELOPMENT OF A CASE STUDY OF THE TOTAL
EFFECT OF PESTICIDES IN THE ENVIRONMENT,
NON-IRRIGATED CROPLANDS OF THE MID-WEST

This study is the result of
Contract No. 68-01-0117 awarded by the OWP,
as part of the Pesticides Study (Section 5(l)(2) P.L. 91-224)
to Ryckman, Edgerley, Tomlinson and Associates, Inc.

The EPA Project Officer was Charles D. Reese, Agronomist

ENVIRONMENTAL PROTECTION AGENCY
Office of Water Programs
Applied Technology Division
Rural Wastes Branch
TECHNICAL STUDY REPORT: TS-00-72-03

June 1972

EPA Review Notice

This report has been reviewed by the Office of Water Programs of the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, or does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Among all environmental pollutants, chemical pesticides have aroused special concern. They are widely used throughout the United States on croplands, rangelands, forests, lawns, turf, in and around homes, for protection of structures and stored products, and over entire areas for mosquito control, insect eradication, imported fire-ant control, and similar area-wide programs. Chemical pesticides include insecticides, fungicides, nematocides, herbicides, rodenticides, defoliants, desiccants, plant growth regulators and similar biologically active compounds. Depending on dosage many pesticides are toxic to humans, animals and other non-target organisms.

Some environmental aspects of some specific pesticides have been studied, but no overall quantitative description and assessment of the pesticide pollution problem has been made. In compliance with Section 5 (1) (2) of Public Law 91-224, however, the Water Quality Office of the Environmental Protection Agency has organized and conducted a series of pesticide studies which are intended to provide a comprehensive analysis of the pesticide problem in the United States.

This particular case study conducted by Ryckman, Edgerley, Tomlinson and Associates, Inc. (RETA) with

Dr. R. von Rumker as Sub-contractor and Project Consultant is concerned with pesticide use on non-irrigated cropland, such as those in the midwestern United States. Pesticides are used in this area extensively for weed and insect control. In such lands, most of the area is subject to run-off and erosion which is seasonal. Generally, the pesticides used in this region attach themselves to organic matter and soil particles which, in turn, are carried off into rivers and streams by erosion. Thus, this region exhibits characteristic problems in pesticide application techniques and run-off losses.

Using all available information, this study provides an in-depth evaluation of the impact on the natural environment of pesticides used for control of specific pests in the midwestern states of Illinois, Iowa, Kansas, Minnesota, and Missouri.

TABLE OF CONTENTS

	<u>Page No.</u>
Title Page	i
Foreword	ii
Table of Contents	iv
List of Tables	vii
List of Figures	xi
Participating Staff	xiii
Special Acknowledgements	xiv
Introduction	xv
STUDY - SUMMARY REPORT	
APPENDIX B - INVENTORY OF PESTICIDE USES	1-B
Selection of Study Area	1-B
Description of the Five State Area	3-B
Pesticide Use in the Five State Area	5-B
Pest Problems in Relation to Pesticide Use	16-B
Summary and Conclusions	21-B
Recommendations	23-B
Literature References	25-B
APPENDIX C - EFFECT OF APPLICATION TECHNIQUES	
Introduction	1-C
Application Techniques	1-C
Reduction of Loss	5-C
Application Equipment	7-C
The Applicators	10-C
Recommended Treatment	14-C
Summary and Conclusions	21-C
Recommendations	23-C
Literature References	26-C
APPENDIX D - ROUTE OF PESTICIDES INTO WATER ENVIRONMENT	
Introduction	1-D
Soil Types	1-D
Transport Routes	5-D
Soil Transport	6-D
Quantity of Pesticides in the Environment	17-D
Other Transport Routes	18-D
Intensive Case Study Area	27-D
Methods of Disposal of Pesticide	
Container and Excess Pesticides	36-D

APPENDIX D (continued)

Monitoring Data	40-D
Summary and Conclusions	46-D
Recommendations	48-D
Literature References	51-D

APPENDIX E - IMPACT ON THE AQUATIC ENVIRONMENT

Introduction	1-E
The Aquatic Ecosystem	1-E
Evidence of Pesticide Accumulation	3-E
Pesticide Entry in Trophic Levels	11-E
Benthic Forms, Zooplankton and Fishes	25-E
Fishes	27-E
Pesticide Degradation	37-E
Validation of Prediction of Harm	43-E
Differential Levels of Pesticide Stores	46-E
Terata	46-E
Behavioral Responses to Pesticides	49-E
Resistance to Pesticides	52-E
Testing with Living Organisms	54-E
Standard Test Water	59-E
Incidence of Injury	60-E
Farm Injury - Human	71-E
Illinois	72-E
Iowa	77-E
Kansas	84-E
Minnesota	86-E
Missouri	86-E
Farm Injury - Livestock	91-E
Iowa Community Pesticide Study	98-E
Aquatic Ecosystems	99-E
Summary and Conclusions	100-E
Recommendations	109-E
Literature References	126-E
	129-E

APPENDIX F - DEGRADATION OF PESTICIDES IN
THE ENVIRONMENT

State of the Art	1-F
Aldrin	1-F
Atrazine	7-F
Summary and Conclusions	12-F
Recommendations	17-F
Literature References	24-F
	26-F

APPENDIX G - ALTERNATIVES TO CHEMICAL CONTROL
OF WEEDS AND INSECTS

Weeds	1-G
Alternatives to Chemical Weed Control	1-G
Insects	3-G
	6-G

APPENDIX G (continued)

Alternatives to Chemical Insect Control	8-G
Diseases	16-G
Summary and Conclusions	17-G
Recommendations	21-G
Literature References	22-G

APPENDIX H - REGULATIONS AND LAWS

	1-H
Introduction	1-H
Federal Organization for Pesticide Control	2-H
State Control Programs	6-H
New Federal Legislation	20-H
Impact of the Pending Legislation	22-H
Testing and Registration of New Pesticides	39-H
State Laws	41-H
Illinois	41-H
Iowa	49-H
Kansas	56-H
Minnesota	68-H
Missouri	82-H
Effects of Laws on Environmental Quality	83-H
Identity of Favorable Types of Laws	112-H
Important Litigation	115-H
Summary and Conclusions	122-H
Recommendations	130-H

LIST OF TABLES

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
<u>SUMMARY</u>		
1	Land Use and Major Field Crops Grown in the 5-State Area	2
2	Estimated Quantities of Major Pesticides Used in the 5- State Area on Corn, Soybeans and Small Grains	3
3	Pesticide Transport Routes	12
4	Pesticide Solubility	13
5	Selected Sediment Measurements in the Five-State Study Area	13
6	Average Soil Pesticide Values	14
7	Disposal Methods	18
8	Comparison of Factors Affecting the Degradation of Aldrin, Dieldrin, and Atrazine	36
<u>APPENDIX B</u>		
1-B	Land Use and Major Field Crops Grown in the 5-State Area	4-B
2-B	Estimated Use of Herbicides and Insecticides on Corn in the 5-State Area	6-B
3-B	Estimated Use of Herbicides and Insecticides on Soybeans in the 5-State Area	7-B
4-B	Estimated Use of Herbicides and Insecticides on Small Grains in the 5-State Area	8-B
5-B	Estimated Number of Acres Treated By State, Type of Treatment, Major Products, and Total Quantities, 1971	9-B
6-B	Estimated Number of Acres Treated By State, Major Products, and Total Quantities, 1971	10-B
7-B	Estimated Number of Acres Treated By State, Major Products and Total Quantities, 1971	11-B

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
8-B	Estimated Number of Acres Treated By State, Type of Treatment, Major Products, and Total Quantities, 1971	12-B
9-B	Estimated Quantities of Major Pesticides Used in the 5- State Area on Corn, Soybeans and Small Grains	13-B

APPENDIX C

1-C	Practices Utilized by Farmers to Erosional Loses From Agricul- tural Land	6-C
2-C	Incidence of Pesticide Drift as Reported by County Agents	8-C
3-C	Problems Encountered with Cali- bration of Equipment Used to Apply Pesticides	9-C
4-C	Proportion of Farmers Who Apply Their Own Pesticides	11-C
5-C	County Agricultural Agents Asses- ment of Commercial Applicator Ability and Training	13-C
6-C	Agricultural Agents Assessment of Recommended Amount of Pesticide Used and Residue Calculations	20-C

APPENDIX D

1-D	Important Pesticide Transport Routes	5-D
2-D	Water Solubility of Selected Pesticides	6-D
3-D	Selected Sediment Measurements in Five-State Study Area	8-D
4-D	Average Soil Pesticide Values	15-D
5-D	Methods of Disposal of Pesticide Containers	38-D
6-D	Manufacturers Instructions on the Pesticide Package as Assessed by County Agricultural Agents	39-D
7-D	Typical Monitoring Data From STORET System - Lower Missouri River	44-D
8-D	Typical Monitoring Data From STORET System - Mississippi Mainstem - Most Recent Data	45-D

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
<u>APPENDIX E</u>		
1-E	Levels of Dieldrin for Water, Sediment and Periphyton, Mississippi River - 1971	14-E
2-E	Concentration of Dieldrin in Periphyton, Mississippi River, 13 May 1971	17-E
3-E	DDT and Residues in Pacific Coast Ecosystems	21-E
4-E	DDT Residues in Carmans River Estuary	22-E
5-E	DDT Residues in Atlantic Marine Fishes and Invertebrates, Canadian Location.	24-E
6-E	Biological Magnification of 14C-Labeled p,p'-DDT and Aldrin by Freshwater Invertebrates	28-E
7-E	Estimated LC-50 Values of Various Insecticides	35-E
8-E	Comparative Toxicities of Insecticides	36-E
9-E	The Mean TL-50 and Coefficient of Variability of p,p'-DDT for fish and aquatic invertebrates	38-E
10-E	Dieldrin and DDT Residues in Whole Fish	47-E
11-E	Affect of Age on DDT Residues	48-E
12-E	Alterations in LC-50 in Natural Fish Population Due to Pesticide Resistance	55-E
13-E	Alterations in Chromosome Frequency in Fruit Fly, California	57-E
14-E	Comparison between Dieldrin and DDT TLM for Four Species of Salmonids	64-E
15-E	Response of Farmers to Incidents of Injury Resulting from Farm Use of Pesticides	76-E
16-E	Status of Reporting of Human Injury Resulting from Pesticide Use by States	78-E
17-E	State Officials Contacted in Five State Study Area	79-E
18-E	Response of Outstate Medical Doctors to Survey of Pesticide Related Injury to Humans, 1970-71	93-E

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
------------	--------------	-----------------

APPENDIX E (continued)

19-E	Reported Poisoning Incidences for the Five State Area	94-E
20-E	Illinois Poison Control Center Data	95-E
21-E	Location of Poisoning Incidences, Five State Area	101-E
22-E	Fish Kills Due to Various Forms of Pollution in Five Study States (1961-1970)	104-E

APPENDIX F

1-F	Comparison of Factors Affecting the Degradation of Aldrin, Dieldrin and Atrazine	19-F
-----	--	------

APPENDIX G

1-G	Summary of Major Weeds Affecting Field Crops in the 5 State Area	2-G
2-G	Summary of Major Insects Affecting Field Crops	7-G

APPENDIX H

1-H	Synopsis of Congressional Tally on H.R. 10729, November 9, 1971	42-H
2-H	Consideration of " <u>Federal Environ- mental Pesticide Control Act of 1971</u> "	43-H
3-H	Litigation Involving Pesticides in Illinois, Iowa, Kansas, Minne- sota, and Missouri, 1956-1971	116-H

LIST OF FIGURES

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
<u>APPENDIX D</u>		
1-D	Major Soils in Five State Study Area	3-D
2-D	Concentrations of Aldrin/Dieldrin Found in Iowa Soils	9-D
3-D	Concentrations of Chlordane/Atrazine Found in Iowa Soils	10-D
4-D	Concentrations of Aldrin/Dieldrin Found in Missouri Soils	11-D
5-D	Concentrations of Chlordane/Atrazine Found in Missouri Soils	12-D
6-D	Concentrations of Chlordane/Atrazine Found in Illinois Soils	13-D
7-D	Concentrations of Aldrin/Dieldrin Found in Illinois Soils	14-D
8-D	Time of Application of Pesticides	19-D
9-D	Measured Persistence of Pesticides in River Water, Organochlorine Compounds	23-D
10-D	Measured Persistence of Pesticides in River Water, Organophosphorus Compounds	24-D
11-D	Measured Persistence of Pesticides in River Water, Carbamate Compounds	25-D
12-D	Measured Persistence of Pesticides in River Water, Comparison of Types	26-D
13-D	Potential Sources of Pesticide Residues in Iowa Waterways	30-D
14-D	Farm No. I	32-D
15-D	Farm No. II	33-D
16-D	STORET Data Point Locations	43-D
<u>APPENDIX E</u>		
1-E	Comparison of Concentrations of DDT and Dieldrin (HEOD) in Two Different Fish	6-E
2-E	Concentration of Organochlorine Compounds in Shags' Eggs at Different Times. O, pp'-DDE; O, HEOD	7-E

<u>No.</u>	<u>Title</u>	<u>Page No.</u>
<u>APPENDIX E (continued)</u>		
3-E	Fate of Chlorinated Hydrocarbons in the Five State Study Area	9-E
4-E	Map of Sample Locations, Water, Sediment, Periphyton	15-E
5-E	Location and Concentration of DDT and Residues Along California Coast and in Sand Crab	19-E
6-E	Kansas Pesticide Alert System - Press Release	87-E
7-E	Kansas Pesticide Alert System - Memorandum	88-E
8-E	Pesticide Alert Bulletin No. 1	89-E

PARTICIPATING STAFF

The following list includes key professional personnel whose efforts have contributed directly to the study of the fate and effect of pesticides used on non-irrigated croplands.

Project Principal

D. W. Ryckman, Sc.D., P. E., President

Project Manager

G. M. Barsom, Sc.D., Assistant Vice President

Project Coordinator

R. M. Matter, Ph.D., Associate

Sub-Contractor and Project Consultant

Rosmarie von Rumker, Sc.D.

Project Staff

D. P. Clement, Environmental Engineer
E. Edgerley, Jr., Ph.D., Senior Vice President
H. D. Tomlinson, Ph.D., P.E., Senior Vice President
F. K. Erickson, P.E., Director of Environmental Affairs
Donald B. McDonald, Ph.D., Consultant
K. W. Axetell, Jr., P.E., Senior Associate
J. W. Irvin, Sc.D., Senior Associate
P. D. Kilburn, Ph.D., Consultant
O. C. Tirella, Director of Finance and Administration
C. J. Pace, Technical Writer
G. K. Lowder, Technical Writer
M. E. Wiese, Manager, Technical Services
M. R. Aron, Technical Writer
P. A. Braden, Senior Typist

SPECIAL ACKNOWLEDGEMENTS

The report which follows is the product of six months of intensive, in-depth research and analyses. The scope of the study necessitated that the Contractor call upon a large number of people and organizations to provide information essential to a comprehensive evaluation of the fate and effect of pesticides used on non-irrigated croplands.

Gratitude is extended to the nearly 10,000 farmers, county agents, university extension services, manufacturers, retailers, commercial applicators, doctors, veterinarians, public officials and congressional leaders who were contacted in the five study states of Illinois, Iowa, Kansas, Minnesota and Missouri. While the names of these contributors are too numerous to list individually, the assistance and cooperation of these citizens was essential to the successful completion of this project.

INTRODUCTION

This study on the fate and effect of pesticides on non-irrigated croplands undertaken by Ryckman, Edgerley, Tomlinson and Associates, Inc. (RETA) had the following objectives:

1. to analyze, describe and document quantitatively the use of pesticides on key mid-western crops including corn, soybeans, and wheat;
2. to evaluate in depth the direct and indirect impact on the water environment resulting from these pesticide uses;
3. to pinpoint areas of actual or potential environmental damage;
4. to provide a basis for systematic correction of such damage to the water environment;
5. to describe applicable local and state laws, and evaluate their effectiveness in preventing environmental damage.

The report is organized to include a summary statement as well as appendix material which provides documentation to support and verify the statements made in the summary. The quantitative information encompassed in Appendices B through H is outlined as follows.

Appendix B, Inventory of Pesticide Uses, includes an inventory and description of pesticide uses in the study area, including types and quantities of major pesticides and the pests toward which they are directed, and a discussion of the historical development of pesticide use within the area.

Appendix C, Effect of Application Techniques, includes a discussion of techniques of pesticide application for the major types of pesticides, with particular emphasis on how these techniques tend to either maximize or minimize run-off problems. Of particular concern in this discussion are techniques which involve the broadcasting of pesticides.

Appendix D, Route of Pesticides Into Water Environment, includes a discussion of the various means by which pesticides move from their original point of application into the aquatic environment. Analyses encompass a discussion of soils and soil types and effects of erosion and sedimentation in the area; the importance of irrigation return flows, overload drainage, transport through atmospheric processes, intentional dumping, accidental spills, sediment transport and the disposal of empty pesticide containers.

Appendix E, Impact of Pesticide Pollution on the Water Environment, provides quantitative documentation of both short-term and long-term detrimental effects associated with the use of one or more specific pesticides used in the study area. Analysis includes the movement of pesticides in the aquatic food chain, pesticide damage to typical biota of the area, the interrelationship of the pesticides discussed, and health hazards to human beings.

Appendix F, Degradation of Pesticides in the Environment, includes analysis of the processes of degradation of specific pesticides in relation to involved water courses, and the toxicity of metabolites and other break down products in terms of the biota of the study area. The quantitative documentation of the persistence of pesticides in the waterways is also included.

Appendix G, Alternatives to Chemical Control of Weeds and Insects, provides an identification and analysis of feasible methods of pest control alternative to the use of pesticides and suitable to the particular study area. Where no alternative can be provided, an identification and analysis of those pesticide uses considered essential is included.

Appendix H, Regulations and Laws, includes a discussion of applicable local laws and regulations governing the use and sale of pesticides. Their effects on

preventing environmental damage have been assessed and an indication given of the types of laws and regulations which could provide adequate environmental protection in this particular geographical area. A discussion of important past legal decisions concerning pesticides in the study area is also included.

SUMMARY

Corn, soybeans, wheat, oats and sorghum are major midwestern farm crops. Corn, soybeans and wheat account for more than 50 percent of total farm use of herbicides in the United States. In addition, corn alone accounts for about 17 percent of total U. S. farm use of insecticides. No major quantities of insecticides are used on soybeans or small grains in the midwestern states. There are no distinct major uses of fungicides or other pesticides on midwestern farm crops. We compared the foregoing breakdown of pesticide uses by crops against a breakdown of the acreage of these crops by states and decided to focus this study geographically on the states of Minnesota, Iowa, Illinois, Missouri and Kansas.

Table 1 summarizes for these five states the major crops grown, total crop acreage and total land area. The totals for each crop are compared to the U. S. total. The five states comprise 9.7 percent of the total U. S. land area, but 26 percent of the total U. S. crop acreage. There are about 88 million acres of farm crops (including hay) grown in these five states. Corn, soybeans, small grains and sorghum combined account for about 73 million acres, or 83 percent of total farm crop acreage in the five states. Forty percent of the

INVENTORY OF PESTICIDE USES

Corn, soybeans, wheat, oats and sorghum are major midwestern farm crops. Corn, soybeans and wheat account for more than 50 percent of total farm use of herbicides in the United States. In addition, corn alone accounts for about 17 percent of total U. S. farm use of insecticides. No major quantities of insecticides are used on soybeans or small grains in the midwestern states. There are no distinct major uses of fungicides or other pesticides on midwestern farm crops. We compared the foregoing breakdown of pesticide uses by crops against a breakdown of the acreage of these crops by states and decided to focus this study geographically on the states of Minnesota, Iowa, Illinois, Missouri and Kansas.

Table 1 summarizes for these five states the major crops grown, total crop acreage and total land area. The totals for each crop are compared to the U. S. total. The five states comprise 9.7 percent of the total U. S. land area, but 26 percent of the total U. S. crop acreage. There are about 88 million acres of farm crops (including hay) grown in these five states. Corn, soybeans, small grains and sorghum combined account for about 73 million acres, or 83 percent of total farm crop acreage in the five states. Forty percent of the

TABLE 1
LAND USE AND MAJOR FIELD CROPS GROWN IN THE 5-STATE AREA
(In 000 Acres)

State	Major Crops Grown						All Other Crops	Total Crop Acreage	Total Land Area	Crop Acreage % of Total Land Area
	Corn	Soybeans	Wheat	Oats	Sorghum	Hay				
Minnesota	5,285	3,129	830	3,354	negl.	3,231	1,671	17,500	50,745	34
Iowa	10,072	5,369	negl.	1,817	negl.	2,496	negl.	19,931	35,868	56
Illinois	10,379	6,865	993	612	negl.	1,260	303	20,412	35,761	57
Missouri	3,114	3,557	1,059	312	290	3,008	negl.	11,400	44,190	26
Kansas	1,637	1,005	9,061	250	4,277	2,364	494	19,108	52,516	36
5 States	30,497	19,945	11,943	6,345	4,575	12,379	2,464	88,351	219,080	40
U.S.	67,171	43,332	47,000	24,312	17,292	63,234	77,659	340,000	2,266,273	15
5 States/ U.S.	45%	46%	25%	26%	26%	20%	3%	26%	9.7	

Note: Data in this tabulation originate from several different sources (128), and some items are not expressed numerically. For these reasons some columns do not balance arithmetically.

total land area in the five states is used for farm crops, while the national average is only 15 percent.

Thus, this five state region is intensively farmed. A high percentage of its total land area is devoted to the growing of crops. Five field crops dominate the scene.

Table 2 summarizes the estimated quantities of major pesticides used in the five state area on corn, soybeans and small grains in 1971. These data were obtained by drawing on a considerable number of different sources of information. The states of Minnesota and Illinois collect and publish annually statistical data on the numbers of acres treated with specific pesticides, but they do not report total quantities of pesticides used. The states of Iowa, Missouri and Kansas do not collect or publish similar state-wide

TABLE 2
ESTIMATED QUANTITIES OF MAJOR PESTICIDES USED IN THE 5-STATE AREA ON
CORN, SOYBEANS AND SMALL GRAINS

	Pesticide	Crop	MM lbs of Active Ingredient
Herbicides:	atrazine	corn	30,000
	propachlor	corn	18,700
	amiben	soybeans	13,600
	alachlor	soybeans	11,450
		7,100}	
		4,350}	
Insecticides:	2,4-D - type	corn	7,025
		3,825}	
		small grains	3,200}
	trifluralin	soybeans	3,970
	aldrin	corn	11,000
	Bux	corn	2,800
	heptachlor	corn	2,660
	phorate	corn	2,364
	toxaphene	corn	2,000
	carbaryl	corn	1,200
	diazinon	corn	662
	DDT	corn	200
	parathion	corn	80

statistics. Pesticide use estimates for these states were made by personal consultations with state extension personnel and other specialists in each state, supplemented by the results of a field survey of pesticide retailers, county agents and individual farmers. State extension service recommendations for pesticide use and manufacturers' label recommendations were also consulted.

Of the approximately 30 million acres of corn grown in the area, about 22 million acres (73 percent) received herbicide treatments. Atrazine is the pre-

dominant herbicide; we estimate that 30 million pounds of this chemical were used in the region in 1971. Pro-pachlor was the next most important product with almost 19 million pounds estimated use.

Of the almost 20 million acres of soybeans grown, about 14 million acres (70.5 percent) received herbicide treatments. In descending order of total quantities used, amiben, alachlor and trifluralin were the soybean herbicides of choice.

Small grains accounted for only relatively small quantities of herbicides used, primarily phenoxy (2, 4-D)-type products.

Control of corn insects is by far the most important insecticide use in this area. Approximately 16 million acres, that is 52 percent of all corn acres in the five states, received insecticide treatments. Aldrin was used in far greater quantities than any other insecticide. Soybeans and small grains did not receive insecticide treatments which would have to be classified as "significant" within the context of this survey.

The use of chlorinated hydrocarbon insecticides in this area has declined, but is still rather substantial. Organic phosphate and carbamate insecti-

cides are expected to increase in use.

The data presented in this report, once published, will be the first detailed compilation of the estimated quantities of major pesticides used in this region.

EFFECTS OF PESTICIDE APPLICATION TECHNIQUES

In this section is presented a discussion of techniques of pesticide application for the major types of pesticides, with particular emphasis being placed on how these techniques tend to either maximize or minimize runoff problems.

Pesticide Applicators, Individual v. Commercial

Pesticide contamination of the environment can be minimized by better application techniques and by a better understanding of the problems and dangers of pesticides. The farmer may apply pesticides himself or he may hire a commercial applicator to do the job for him. Both groups could benefit from instruction.

The contractor's survey indicates that about three-fourths of the farmers apply their own herbicides, and about half apply their own insecticides.

The contractor asked county agents of their evaluation of custom applicators. Agents responding in the five-state study area gave some interesting responses: (1) Slightly more insecticides than herbicides are commercially applied; (2) "...I know he [the applicator] has had training ... but he doesn't act like it;" (3) Most agents have had training and are licensed but their staff who do the work often lack sufficient training; (4) minimum training and performance standards should be adopted for custom applicators and farmers who apply their own pesticides.

Pesticide Treatment Dosage Rates

Most county agents from Illinois, Iowa, Minnesota, and Missouri feel that farmers do use the recommended amounts of pesticides. Cost is the deciding factor. Relatively more agents from Kansas feel recommendations may not be followed. Pesticide residues may remain on a field over a year, but few farmers take this fact into consideration when calculating the amount of pesticide to apply. For example, professional agriculturalists have estimated a 25 percent dieldrin residue from year to year. The agents in Illinois, Iowa, Kansas and Missouri point out that no one has given the farmer a

method to make this evaluation. The farmer is not at fault here; he simply lacks one of the tools to make his operation more economical.

It is sufficient to add that any consideration of existing residue levels and the addition of these levels to any current crop years pesticide use anticipated could amount to a considerably savings to the environment and especially the aquatic ecosystem.

The farmer applies or has applied pesticides as an insurance policy on his crops. Whole crops are treated when perhaps 10 percent of the acreage really needs the benefits of the chemical. The manufacturers of pesticides promote these operations with lavish advertising and skilled salesmen in the area.

Farmers could learn to use less pesticide and to apply them selectively but the present system of sales and application equipment all team up to fight such an approach.

Application Techniques

Most pesticides come in one or more of four forms: (1) liquid, (2) wettable powder, (3) powder, (4) granular pellets. Liquids and wettable powders are mixed with water or oil, then applied with a sprayer. Granular

pellets are applied directly to the soil. Powdered pesticide is mixed with the soil for direct application.

Pesticides are applied during one of three periods: (1) before planting; (2) before the plant emerges; or (3) after it has broken the ground. Application is usually made on an entire field of planting. Farmers have the choice of: (1) "broadcasting" pesticide over the entire field, or (2) "banding" it along narrow rows where the crop is planted. Banding is a means of reducing the amount of pesticide used. Typically, only seven inches out of 30 inches are treated. Both the banded and the broadcast materials may be left on the surface or incorporated into the top few inches of the soil. Incorporation provides a means of isolation from direct exposure to the weather and thus helps minimize potential loss and potential damage to the environment.

A group of farm journals (1) surveyed their readers to find the methods of application which farmers prefer. Seventy percent of the farmers broadcast herbicides on corn. Although the survey showed that an average of 77 percent of the farmers band their corn insecticides, in three of the five study states, the contractor's survey indicated 90 percent of the farmers follow this practice. These data substantiate the prevalence of banding pesticides.

Banding versus broadcasting does not per se affect environmental contamination, rather the auxiliary matters of form the material takes, burial or exposure, pressure, distance to ground, and temperature of a spray effect the application efficiency and thus the amount lost to the environment.

Spraying can be modified to release the spray at or below ground level and thus reduce drift greatly. Spraying on a cool day with low wind will help also. The greatest reduction in application loss can come in the form of granular application instead of liquid application.

Applying the correct amount of pesticide to the soil is important. Any amount greater than the minimum required can only increase the possible damage to the environment. The contractor asked 331 farmers in the five-state study area how their application equipment works in terms of calibration of rates.

Based upon these results, the contractor believes closer inspection of the problems encountered with calibration of equipment is warranted. Agents and retailers indicated that this problem comes up every crop season. The farmers themselves feel they have few problems with calibration. However the number of farmers

indicating occasional calibration problems suggests that there is a continual minor problem with equipment. Many of the farmers contacted had ingeniously modified their equipment to implement application. It would appear that manufacturers and agricultural engineers could contribute by attempting to fit more uniform granular formulations to better engineered application equipment.

Reduction of Pesticide Loss Following Application

There are several methods which a farmer can use to reduce run-off from his land and the concurrent loss of pesticides. One of the easiest ways is to apply granular pesticides and cover them as soon as they are applied.

Banding of pesticides reduces pesticide run-off by reducing the area to which the material is applied, but is difficult to do once the crop has emerged. Research into ways of efficiently combining banding with cultivating could solve this problem.

By reducing run-off itself through minimum tillage, and terracing of grass in natural waterways in the field instead of cultivating the waterways, run-off carrying pesticides can be reduced.

About 87 percent of the farmers contacted by the contractor do try to reduce erosion by some means.

However, their efforts are not coordinated nor maximized. The survey does indicate a knowledge and a willingness to cooperate.

ROUTE OF PESTICIDES INTO THE WATER ENVIRONMENT

This section includes a discussion of the various means by which pesticides get from their original point of application into the aquatic environment. It includes an analysis of the relative importance of irrigation return flows, overland drainage, transport through atmospheric processes, intentional dumping, and accidental spills. The transport of pesticides associated with sediment transport and the disposal of "empty" pesticide containers is also included. The thrust of this section is toward laying the groundwork for control of pesticide pollution through control of the above-mentioned processes which are responsible for pesticides reaching the water environment.

Mechanisms and Relative Importance of Pesticide Transport Routes

Several pesticide transport routes are known to contribute to the presence of pesticides in surface waters. These routes are summarized and ranked below. A concerted

program to develop effective counter-measures and an enforceable implementation plan for control of pesticide pollution through control of the above mentioned processes must receive a top Federal priority.

TABLE 3
PESTICIDE TRANSPORT ROUTES

RANK*	ROUTE TO THE ENVIRONMENT	RELATIVE SIGNIFICANCE
1	Overland Drainage •Adsorption & movement on sediment •Solubility in water	Great, dominant route Moderate
2	Atmospheric Processes •Evaporation during application •Evaporation from land •Drift	Great Moderate Great (potentially)
3	Empty Container Disposal	Great (potentially)
4	Intentional Dumping	Great (potentially)
5	Accidental Spills	Moderate (potentially)
6	Movement in Groundwater	Low
7	Irrigation Return Flows	Not applicable to non-irrigated land

*in descending order of importance

Soil and Sediment Transport

The table below shows the water solubility of the three most widely used pesticides in the study states.

TABLE 4

PESTICIDE SOLUBILITY

Compound	Solubility
Aldrin	11 ppb
Dieldrin	110 ppb
Atrazine	33 ppm

These low solubilities indicate that pesticides do not travel as a water solution, but rather are carried in suspension as an emulsion or more commonly adsorbed on soil and sediment particles. The contractor's study has confirmed that pesticide adsorption on sediment is the main route of pesticides into the aquatic environment. Therefore the amount of sediment carried in surface waters is a critical route of pesticides to the aquatic environment. The U.S. Geological Survey has reported the sediment measurements (shown below) in the five-state study area.

TABLE 5
SELECTED SEDIMENT MEASUREMENTS
IN FIVE-STATE STUDY AREA

Place	River	Amount of Sediment (tons/year) (6)
Mankato, Minnesota	Minnesota	820,211
St. Louis, Missouri	Mississippi	118,358,500
Red Oak, Iowa	E. Nishnabotna	1,576,799
Chariton, Iowa	Chariton River	56,209
Winfield, Kansas	Walnut River	1,015,712
Arkansas	Arkansas River	1,598,572
Wanego, Kansas	Kansas River	1,104,402

The total pesticide load in river sediment can then be estimated by correlating these sediment loads with average pesticide concentrations found in river sediment. Measured sediment values for dieldrin in Iowa ranged from 1.7 to 35 ppb, with an average of 11.1 ppb. If this amount of dieldrin was in the sediment load passing St. Louis, the total annual dieldrin pesticide load would be 260 pounds.

Many factors may influence the soil's capacity for pesticides including organic content, pH, colloidal clay, cation exchange capacity, and moisture retention. Usually organic carbon correlated better with pesticide levels than any other parameter.

The following table shows average values of aldrin, dieldrin and atrazine found in Illinois, Missouri and Iowa, as reported by the U.S. Department of Agriculture (USDA).

TABLE 6
AVERAGE SOIL PESTICIDE VALUES

State	Compound	Value (ppm)
Illinois	Aldrin	0.147
	Dieldrin	0.138
Missouri	Aldrin	0.133
	Dieldrin	0.129
Iowa	Aldrin	0.07
	Dieldrin	0.107
	Atrazine	0.05

Although it is difficult to measure pesticide residues in soils and they are subject to extreme variability over even small areas, these USDA figures are still useful. When these figures are related to measured sediment carried in the Mississippi at St. Louis, resulting calculations show that about 10 tons of dieldrin are annually carried in the Mississippi at St. Louis. Better measurements and a more comprehensive monitoring program are needed before more accurate conclusions can be drawn about the quantity of pesticides in the water environment.

The contractor's survey determined that farmers apply the largest portion of their yearly pesticide dose when run-off is most likely to occur. The U.S. Geological Survey (USGS) 30-year river discharge patterns for three rivers in Iowa was correlated with pesticide application in these areas. The data show peaks in the same months farmers apply pesticides. Since high discharge means large run-off from the fields with corresponding high sediment transfer rates, from an environmental standpoint, pesticide application comes at the worst possible time of the year. This same phenomena is true in each of the other study states.

Atmospheric Transport Routes

Lloyd Harrold (2) in Ohio has measured loss from drift of spray-applied dieldrin. He reported a 25 percent loss in material application, although it was into three inches of soil the day of application.

Generally, drift is a minor problem because of the short distance involved. However this could be a potentially serious local problem if a water body was located within drift distance. Improved application techniques could minimize drift.

Frost and Ware (3) measured drift produced in aerial spraying as opposed to ground spraying and found that the former produced four to five times as much drift as the latter. On the ground one large nozzle produced less drift than three smaller units while covering the same area.

Thus spraying from the ground using equipment with a few large nozzles rather than several small ones produces less drift.

Lloyd (2) , Caro and Taylor (4) of Ohio also measured evaporation of dieldrin from farm land and found that two percent of the dieldrin evaporated during the year of application. Spencer (5) confirmed these findings for dieldrin and lindane.

Pesticide Monitoring Data

Pesticide monitoring presently consists of haphazard, disorganized data collection. The current program does not detect pesticides at concentrations greater than a few parts per trillion, levels which ten years ago were undetectable by most techniques and levels which have not been shown to be harmful to man.

A comprehensive data collection system sensitive to the parameters influencing pesticide movement - runoff and sediment and weather conditions - must be developed. The contractor proposes in the recommendations section of this report a series of intensive study areas in small watersheds supplemented by daily measurement of pesticides from large municipal water treatment plants on major rivers.

Methods of Disposal of Pesticide Containers and Excess Pesticides

One of the biggest potential problems associated with the use of pesticides is the disposal of their containers. The contractor's survey to determine disposal methods utilized by farmers is shown below:

TABLE 7
DISPOSAL METHODS

RANK*	DISPOSAL METHOD	COMMENT
1	Burn	Containers burned with other trash in open fire
2	Wash & Save	Containers rinsed out and stored or reused
-3	Throw in Trash	Containers thrown for pick-up with other solid waste
4	Bury	Farmer buries containers on his property
5	Discard	Farmers throws containers in ditch or field edge

*in order of frequency of use

All of these disposal practices are potentially dangerous to the environment. Burning containers is recommended by most manufacturers but reliable estimates suggest temperatures obtained in open burning, practiced by farmers, are insufficient to destroy the compound.

A large number of farmers still continue to wash old containers and use them for general purpose farm pails, despite specific warnings against such practices.

Disposal of containers in a town dump has similar drawbacks to burying. Leakage of contaminants and subsequent contamination of ground and surface waters is a problem.

Burying the containers appears to be the least

harmful of all disposal techniques, if care is taken to assure that containers are buried where contamination of ground or surface waters cannot result. However, there is no procedure to insure effective burying practices.

At the present time there is no effective practical method of empty pesticide container disposal.

To confirm the lack of practical container disposal methods, farm agents in the five state area were asked if they felt manufacturer's application instructions and instructions for container disposal were understandable and practical. Most agents felt the application instructions were understandable and practical to follow for proper usage. In general, the farm agents felt container disposal instructions were understandable, but felt strongly that disposal instructions were impractical for the average farmer to follow.

IMPACT ON THE AQUATIC ENVIRONMENT

Very little is known about the effects of various pesticide compounds on the total aquatic environment. Part of this general inability to properly assess environmental damage comes from the lack of sufficient knowledge of the intimate, subtle and extremely complex functioning of aquatic ecosystems. Sufficient information is presently at hand to indicate that environmental

damage has occurred, is occurring, and despite what we do now, will continue to occur for some period of time.

The contractor feels sufficient knowledge is at hand now to set forth the following summary and conclusions relating to impact on the aquatic environment.

Persistent pesticide compounds do not disappear after application. They may remain for variable periods of time, hopefully fulfilling the task that they were designed for: the destruction of agricultural pests, potential disease vectors, and other noxious pests of all varieties. Concomitant with application and again for varying periods of time and at differing rates, these compounds co-distill, vaporize, adsorb on inorganic and organic particles and are absorbed into living material where they may be altered chemically, exert an often unidentified influence over the living tissue, be stored with no apparent harm, or eliminated to the environment.

It has been shown that some kinds of pesticide compounds have been found in almost every kind of living material when looked for. The key word here is when, for many of our informational gaps are the result of simply not having had the time or the money or the experience to measure all aspects of our global biota. It is significant that no ecosystem, terrestrial

or aquatic, has been found free of these compounds no matter whether it be simple or complex. It is also well to remember that even the most "simple" ecosystem has, upon closer inspection, been found to be extremely complex. It can truthfully be said that we really do not fully understand the complete biochemical or molecular nature of even the most "simple" such system. It is highly unlikely that we ever will.

Implicit in an appreciation of the trophic dynamic structure of any ecosystem is the concept that, in addition to energy, other compounds are transferred from one trophic level to the next. One of the difficulties in developing a full appreciation for pesticide involvement in trophic structure is that any trophic level can and does acquire additional qualities completely independent of any other level. This is accomplished most commonly by ingestion or absorption from the surrounding environment.

Thus we find that the primary producer group of photosynthesizing plants of the aquatic environment have the ability to accumulate these compounds from the water. The metabolism and the degree of degradation accomplished by these plants is poorly understood at this time. Although not all groups respond in the same fashion, some exposures have resulted in a reduction of

photosynthetic rate in both marine and fresh water algae.

Zoo plankton have shown a variety of responses to pesticide exposure. Species susceptibility within the same taxonomic group varies from almost no effect to complete intoxication and death at similar exposure levels. Although some experiments have been conducted and many more are either being conducted now or planned for the future, our knowledge of the response of natural populations of zoo planktons to environmental levels of pesticides is quite inadequate. Long term chronic exposure to sub-lethal "natural" levels as are being conducted by the Federal Fish Pesticide Laboratories and independent investigators are vitally needed to identify effects on longevity, productivity, and intrinsic rates of natural increase. Such additional information is required to properly assess the effects of environmental variables, such as temperature, pH, water hardness, and other water quality factors, and the synergistic effects of combinations of other potentially harmful compounds. Prodigious quantities of these organics are consumed by higher trophic levels. The combined production of zoo plankton must be maintained to support sustained yield of higher forms. A significant degree of biomagnification is observed by virtue of the critical quantities consumed

as well as from the environment.

Benthic organisms like some zoo planktons now occupy different trophic levels depending upon their age and life style. Vegetarian species are obviously primary consumers, while omnivores or strictly carnivorous species may be primary consumers as young or primary or secondary consumers as adults.

The literature is clear that these forms can accumulate pesticide loads far in excess of the levels below them. Considerable species variation as well as differences between genera and family can be seen relative to the ability to "withstand" certain levels of pesticides. At the present time, an insufficient number of different organisms have been examined carefully enough to identify the effects of long term sub-lethal exposure. Frequent examples of virtually complete denudation of streams have been observed following heavy applications of pesticides. Repopulation of these diminished areas within a year are given as evidence of no real harm. Repopulation by this nominally very mobile group of crustaceans and essentially aerial insects should not surprise anyone. We do not know what effects chronic sub-lethal exposure has on rates of feeding, food conversion, reproductive success or growth and longevity. Basic experiments which have been performed suggest that sub-lethal exposure for periods of

up to one or two hundred days are harmful to zoo planktons and benthic forms in terms of growth and viability. Higher trophic levels are usually composed of vertebrate organisms. The smaller members (minnows and other forage fishes) usually have a relatively short life. Thus, individually they may not accumulate a tremendous body burden during their lifetime. Larger organisms (predaceous and piscivorous fishes) live longer and consumer many smaller organisms, thus accumulating much higher burdens in their lifetimes. One of the things that is so difficult to assess in the aquatic ecosystem is relative lack of fitness. If organisms from any trophic level have been weakened or debilitated in any way, they are far more susceptible to capture, disease, or parasitic infection. The possible effects of low level chronic exposure resulting from potentially harmful pesticides are more easily eaten and thus removed from our scrutiny.

Larger aquatic vertebrates have generally been studied longer and have more known about them than the lower trophic levels. This fact, plus the fact that they are usually economically more valuable to man, has resulted in a considerable body of information on pesticide effects to this group. Admitting that acute exposure levels are necessary to establish guidelines

for water quality and to protect the stocks of fishes to some extent, we would nevertheless like to stress the results of chronic sub-lethal exposure.

It has been demonstrated that long term sub-lethal exposure to some chlorinated hydrocarbon compounds does produce teratogenic effects in a number of valuable species of fishes. The extreme case is demonstrated by the loss of entire broods of Atlantic salmon at the time of hatching, following exposure of the parents. Numerous examples harm warm water fishes, particularly pond stocks of channel catfish, show increased levels of malformed and dead young, resulting from exposed parental stocks. Transovarian movement of many of these compounds have been demonstrated for mammals, birds and fishes; it is assumed to be a vertebrate phenomena varying only in degree between class and species.

It appears that behavioral abnormalities can result to fishes from exposure to chlorinated hydrocarbons. Some of the experiments at very low sub-lethal levels are only noticed when the most sophisticated electro-physiological measurements are conducted. The fact that many lay people do not understand what this kind of technology means does not detract from the potential for harm to these organisms. Likewise learning behavior has been reported as lessened in chronically exposed

fishes. No data is available for other aquatic life.

Endocrinological alteration, especially in pituitary and adrenal function, have been noted. These effects may have far reaching effects on the life of individuals as well as the perpetuation of the species.

Hepatic microsomal enzyme induction has been recorded for other vertebrates as well as for fishes. The resulting disturbance of steroid metabolism is well documented. Evidence has been presented which indicates that variations in respiratory rate affect the uptake of certain chlorinated hydrocarbons. We know nothing about the pharmacodynamics of uptake or diffusion rates as they relate to variations in water chemistry. Alterations in protein metabolism have been demonstrated in fishes and other vertebrates. This may be a reflection of the hepatic microsomal enzyme response. It may be particularly important in fishes as a vertebrate group since these animals seem to be adapted specifically to the metabolism and elimination of nitrogenous compounds.

Some of the most striking effects to fishes have been the result of studies which showed no apparent harm under regimens of chronic sub-lethal exposure. When starved or when conditions exist that require the animal to draw on body stores of fat or protein for energy, the resulting concentration of stored material exerts

its effect; reduced vitality, decreased muscular ability, disturbed metabolism and death are observed.

Research in metabolism of cold blood organisms have lagged behind mammalian and bird studies. Little is known of how fast or to what extent body stores of fat are mobilized by stressed aquatic organisms. Serious question is raised as to the suitability of acute and chronic exposure studies in aquatics as they have been conducted. Certainly additional research is required in this area.

Osmoregulation and osmoregulatory ability is more of a problem with aquatic animals than terrestrial. It is for this reason that alterations in kidney function and disturbed osmoregulatory ability under conditions of chronic exposure to chlorinated hydrocarbons pose such a threat to this group.

The choice of experimental animals is often dictated by availability as much as general suitability. Although mechanisms do exist at the Federal level for specifying the nature of information to be supplied the manufacturer for registration of a compound, it is felt that these criteria are in need of complete revision and certainly must be expanded to include experiments and measurements designed to better sense the impact on the environment. In this connection it is particularly

important that additional non-target species be included.

Those organisms which constitute the decomposer group (bacteria, fungi, and other microbes of soil and water) have been demonstrated to exert a limited effect on the degradation of persistent pesticides in natural environments. Under laboratory conditions, groups have been identified which will degrade to some extent; often the degradation products are more toxic than the parent compound. Our total information in this area, particularly from natural environmental conditions, is particularly meager.

The literature is clear in the picture it presents of global contamination of our abiotic and biotic ecosystems. All trophic levels carry body burdens -- whether the persistent compounds kill outright or only reduce trophic level efficiency is still open to question. In any event, it is clear that biomagnification does occur between successive trophic levels, additional bioaccumulation can and does occur at each trophic level. The result is one of sufficient body burdens of these compounds at the highest levels to cause death, debility, reduced reproductive success, reduced mental alertness and a generally disturbed physiology, all tending to reduce the biological fitness of the animal to meet the demands of the environment.

Studies with laboratory mammals suggest the possibility of harm to the human animal. It must be stated that no adequate demonstration of clinical manifestation of carcinogenicity, mutagenicity or teratogenicity has been shown for humans, resulting from chlorinated hydrocarbon exposures at low levels commonly encountered in the environment.

Acute toxicity has been demonstrated with some compounds at high levels and should not be surprising in view of their poisonous nature.

There is mounting evidence of past careless use of organo-phosphate compounds. Clearly industry and all segments of agriculture and agribusiness must dedicate themselves to better education of the users of these chemicals. Additional research is urgently needed to make use and particularly application safer for the general user.

Farm Injury - Human

County agents, farmers and doctors in the five study states were surveyed to determine the extent of possible harm to farmer/applicators from the handling of pesticides. About twenty-five per cent reported knowledge of particular incidences of pesticide-exposure-related illness within the past year. Twenty-five per cent of the doctors responding indicated they had treated patients for

pesticide-related symptoms. Of these, 65 per cent were from organo-phosphate poisoning.

The greatest causes of illness were: (1) spray drifting back on the operator; and (2) contact with pesticide due to mechanical breakdown of the equipment. Phorate and disulfoton fumes were most often singled out as being responsible for operator illness. In all cases reported by County agents, operator carelessness was blamed as primarily responsible for the exposure to pesticide. In many cases agents indicated they had cautioned farmers to use protective clothing, but the warning went unheeded. These results confirm earlier reported findings that most accidental exposures are the result of improper application or obvious disregard of adequate safety measures. Containers and label directions, although superficially adequate, do not draw sufficient attention to the dangers or are not practical for the farmer to follow. This situation, compounded by the applicators' reluctance to utilize safety clothing, plastic gloves, respirators, etc. create a potentially hazardous medical situation.

The contractor contacted state health officers or offices and/or state officers in charge of poison control centers, state pesticide officers, vector control authorities, state veterinarians, bureaus of

hazardous substances and similar agencies in each of the five states. Representatives of these agencies were asked: (1) Are there pesticide-related illness not being reported? (2) Are doctors reporting pesticide-related illness to health agencies? and (3) What kinds of damage to wildlife and livestock go unreported?

Illinois

There is a lack of machinery and enforcement for reporting pesticide-related illness. No systematic procedure exists for reporting this kind of injury, however, the educational material and short courses conducted through the University of Illinois, along with an aggressive program of farmer education, appears to be quite good.

Iowa

Dr. Keith Long of the Institute for Agricultural Medicine conducted a postcard survey of farmers. Of the 1100 replies, 900 reported treatment for pesticide exposure of some kind. For the same time period, poison control centers and hazardous substance centers in the State of Iowa reported only 37 cases. These results indicate the entire problem of injuries from pesticide use is far greater in magnitude than previously anticipated.

Kansas

All contacts from state offices indicated there were no records system other than the Poison Control Center. Kansas has initiated the Kansas State Pesticide Alert System to provide a workable early warning system for those concerned with pesticide use.

Minnesota

A study of commercial/aerial applicators completed in the summer of 1971 indicated that although these men are not fully aware of the potential harm from the use of insecticides, ground crewmen hired to assist applicators have the greatest possibility of harm. However, good insecticide sprayers, because of a lack of rigorous enforcement from the State Department of Agriculture, are subject to greater harm than aerial sprayers.

Missouri

At present, Missouri has no mechanism for reporting or recording incidences resulting from pesticide use.

In summary, the five study states have rather poor systems for identifying the problems of health hazards from pesticide use. It is significant that none of the states has a standard reporting system for injury or

illness related to pesticide exposure. The Kansas Alert System appears to offer the pesticide user: (1) a closer working relationship between various involved agencies; (2) prediction of possible hazards to human health; (3) valuable recommendations on pesticide application rates; and (4) potential dollar savings to farmers and decreased hazard to the environment.

Farm Injury - Livestock

Contacts with veterinarians and other state officials by the contractor has indicated there is no adequate system for reporting or caring for farm animals exposed to pesticides. In many cases, field diagnosis is inaccurate and after death of the animal, measurements are usually not made. The general philosophy seems to be that "a dead cow is a dead cow -- who is going to pay for an autopsy."

Damage to the Aquatic Ecosystems

Adequate reporting and recording of local incidences of pesticide "damage" to the waterways does not exist in the five state study area. Although dead fish and invertebrates are observed, they are seldom reported. This attitude is borne out by Federal reports of fish kills which are filed only when the incident is sufficiently great.

County farm agents were surveyed to assess the extent of possible pesticide damage to farm water supplies. Not surprisingly, a very small number of incidences were reported. State conservation officials contacted declined to cite figures but all indicated that the County Agent reports were far too low.

Reports to the EPA for the period of 1960-1970 do not cite pesticides as a major contributor to fresh water fish kills. Pesticides are responsible for less than 10 per cent of the total losses (except in Minnesota, where the total number of animals is rather small), while feedlot and fertilizer damage may run up to 50 per cent of the total. In Missouri, mining practices account for up to 50 per cent of the total fish kill reported.

Despite improvements in the reporting system, it is doubtful if it will be adequate to effectively monitor pesticide damage to public waters.

DEGRADATION OF PESTICIDES IN THE ENVIRONMENT

In line with the increasing concern about pesticides and their possible impact on the environment, a number of recent conferences, panels and committees have addressed themselves to this problem. A large volume of literature on this subject has been exhaus-

tively reviewed, abstracted and commented upon in the recent past. It is the general consensus of these comprehensive studies and reviews that present pesticide use patterns do not adversely affect human health directly, but that they cause adverse effects on certain species of wildlife, and further actual or potential environmental harm whose nature and extent may escape our present capabilities of detection and/or foresight. Many scientists working in this area are increasingly concerned about possible long-term low-level environmental effects.

Based on their volume of use on midwestern farm crops and on their physical, chemical and biological properties, we selected the insecticide aldrin and the herbicide atrazine for a more extensive review of information on their degradation in the environment.

Table 8 presents a summary and comparison, probably over-simplified, of the factors affecting the degradation of aldrin, dieldrin (the principal metabolite of aldrin) and atrazine. There are important differences in the physical and chemical properties of these compounds which in turn influence their persistence, degradation and propensity for environmental damage.

Among pathways of "disappearance" from the site

TABLE 8

COMPARISON OF FACTORS AFFECTING THE DEGRADATION OF
ALDRIN, DIELDRIN AND ATRAZINE

Factor	Aldrin	Dieldrin	Atrazine
Volatilization	substantial	small except when on surface	occurs, probably not substantial
Metabolism	epoxidation	not known in detail	not known in detail
-major metabolite(s)	dieldrin (15-30%)	"photo-dieldrin", diol-compound	hydroxy-atrazine
Leaching	No	No	Yes
Surface runoff			
-in water	negligible	negligible	Yes; may be substantial
-on solids	may be substantial	may be substantial	Yes
Wind erosion	possible	possible	possible but probably minor
Microbial degradation			
-aerobic	demonstrated in the lab, but not confirmed in the field	demonstrated in the lab, but not confirmed in the field	possible but probably minor
-anaerobic			
Non-biological degradation	Yes	Yes	substantial
Av. Half-life in soil	1 year	1 year	1 year
Vapor pressure	6×10^{-6} mmHg at 25°C	1.8×10^{-7} mmHg at 25°C	3.0×10^{-7} mmHg at 20°C
Lipid solubility	High	High	Low
Water solubility	0.027 ppm at 25°C	0.186 ppm at 25°C	33 ppm at 27°C
Stability to hydrolysis			
-alkaline	stable	stable	stable in neutral
-acid	stable with dilute acids	stable with dilute acids	and slightly alkaline or acid media

of application, volatilization is one possible escape route of aldrin. It has the highest vapor pressure of the three chemicals in this comparison. Volatilization of atrazine may occur, but it is not believed to be substantial.

The exact pathways of metabolism and degradation and the nature of the ultimate breakdown products are essentially unknown for all three chemicals.

Leaching and surface run-off as a solute in water are not likely in the case of aldrin and dieldrin, but may be substantial in the case of atrazine because of its relatively high water solubility. Adsorption on solids and consequently, transport by soil erosion or wind erosion are possible routes of escape for all three products.

Microbial degradation has been demonstrated in the laboratory, but not confirmed in the field for aldrin and dieldrin. It is possible but probably minor in the case of atrazine.

Non-biological degradation occurs with all three products, probably to a substantial degree, especially in the case of atrazine.

Both aldrin and atrazine have been in large-scale commercial use for many years. Yet, disturbingly little is known about their fate in the environment after appli-

cation, or about their pathways of metabolism and degradation under field conditions. Information on their effects on non-target species consists largely of data on the amounts of chemical lethal to various test organisms, in the majority of cases obtained under laboratory conditions. There is very little information on possible interactions between these pesticides and/or their metabolites with other chemicals. Practically nothing is known about possible effects of long-term low-level residues of these pesticides and/or their metabolites on the environment in general, or on aquatic ecosystems in particular.

Thus, it is obvious that there are glaring gaps in our knowledge of the environmental behavior of these important pesticides. The type of research required to fill these gaps will be complex, and it will be successful only if it is planned and performed by an interdisciplinary approach.

The emphasis must be on studies under actual field conditions. Every effort should be made to encourage interdisciplinary teams to engage in comprehensive research on complete ecosystems. Work on isolated organisms in the laboratory, far removed from field reality, with which the present literature is filled is of relatively limited value unless its significance in regard to field conditions can be clearly assessed.

In this connection, it must be recognized that the more comprehensive, interdisciplinary approach is not liable to produce material suitable for quick publication of simple results. The publishing incentive systems in the academic world may require some adjustments in this regard.

The examples of the triazine symposium (6) conducted by the University of California at Riverside in cooperation with the product's manufacturer, as well as the symposium on "pesticides in the soil" conducted at Michigan State University through Guyer's (7) initiative demonstrate how useful such work conferences can be in pulling together all available data and expert opinions on a complex problem. Prerequisites for success are selection of a sufficiently narrow and well-defined subject, good preparation and execution of the conference, and timely publication of the proceedings, preferably with a good index.

ALTERNATIVES TO CHEMICAL CONTROL OF WEEDS AND INSECTS

Field crops in the five state area are affected by a considerable company of weeds, predominantly annual species. However, perennial weeds are slowly becoming more prevalent since the annual weeds are so effectively controlled by chemical herbicides.

There are no specific non-chemical agents such as "beneficial insects" available for control of any of the weeds in this region, and no significant work in this direction appears to be in progress. However, it is noted that weed control at the farm level does not rely exclusively on the use of chemicals, but has always been carried out by the integrated use of many farming practices such as crop rotation, tillage, selection of planting date, etc. This system was not abandoned when chemical herbicides arrived, but these products were included in it.

One of the elements important to good "integrated control" practices is information on economic damage thresholds. Considerable attention has been devoted to this question by scientists in the area, and their work has provided useful data on the relationships between weed infestations and yields of the major field crops.

By far the most important insect problem in the five states are corn rootworms and soil insects on corn. Much effort has been focused on the search for alternate methods of insect control in general, but soil insects have not received much attention in this regard thus far. To the best of our knowledge, there are no realistic prospects that microbial, hormonal or

other agents for selective control of soil insects will be available in the foreseeable future.

All three economically important species of the corn rootworm occur in the five state area. The northern and western species are highly resistant to chlorinated hydrocarbon insecticides and increasingly resistant to some organic phosphate insecticides. Corn rootworms are most damaging in "continuous corn", i.e., when corn is grown without rotation with other crops. The development of corn varieties more tolerant to the effects of corn rootworm feeding is the most promising lead as an alternative to the use of chemicals. However, improved varieties with these desirable corn rootworm resistance features are not yet available. Crop rotation to break the insects' life cycle is a presently available alternative, but it is not economically attractive to many corn growers.

In the past, the European corn borer caused major damage to corn in the midwest. DDT was used extensively to control it. Much success has been achieved in the development of corn hybrids resistant to this insect.

The "soil insect complex" which includes white grubs, wireworms, sod webworms, corn billbugs, cutworms seed-corn maggots and seed-corn beetles is most damaging to corn grown after sod, pasture, forage crops, etc. Chlorinated hydrocarbon insecticides still are used

heavily against this complex. There are no practical leads to specific non-chemical methods or agents for the control of these insects. At the same time, they occur so erratically and infrequently that entomologists experience great difficulty in conducting meaningful performance trials against them. Many entomologists agree that a large portion of the insecticides applied for this purpose, probably as much as 90 percent, is applied needlessly. Discontinuation of this practice would eliminate a major source of environmental contamination in this area.

Soybeans in the five states are not presently affected by major insect pests requiring routine insecticide treatment. However, entomologists anticipate that the increasing intensification of soybean growing practices will bring about greater insect problems on this crop in the future. This situation where a major crop is not yet subject to routine insecticide applications presents a unique challenge and opportunity for the development of suitable "pest management" systems from the outset. In this area, there is a great need for practical, down-to-earth approaches, including development of insect damage threshold data, insect damage forecasting, improved weather forecasting, and establishment of the organizational requirements and structures necessary for effective programs.

Furthermore, in order to use chemical insecticides to best advantage as one element in an integrated system, information is needed on the spectrum of selectivity and the degree of effectiveness of potentially useful products at the low end of their dosage range. The use of presently available insecticides at lower dosage rates is one reservoir of selectivity which is still largely under-utilized, if not completely untapped today.

APPLICABLE LAWS AND REGULATIONS

The contractor has endeavored to examine and present in concise form, the status of federal and state laws directly pertinent to the five-state study area. By collecting and analyzing pertinent laws at the state and federal level, and through a series of interviews with key people, a picture of good and bad has been assembled; each will be presented with the contractor's evaluation of areas of needed reform.

The federal regulation of pesticides operates under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), enacted in 1947 and amended in 1959, 1961, and 1964. The act prohibits the interstate or international shipment of economic poisons unless they are: registered pursuant to provisions of Section 4

of the act; are in unbroken immediate containers; and are labeled according to the provisions of the act.

Should the Administrator find that an imminent hazard to the public would exist, he may suspend the registration of an economic poison immediately. Any person who violates this law may be found guilty of a misdemeanor and on conviction can be fined not more than \$1,000.00.

New Federal Legislation

During 1971, Congress has considered legislation to amend or replace FIFRA. At least eight different bills dealing with pesticides were introduced in the House of Representatives. The primary one was H. R. 4152. In the Senate four bills have been under consideration, two of which (S. 600 and S. 745) would - like H. R. 4152 - replace the present FIFRA. The other bills would either prohibit the sale of DDT or prohibit the sale of aldrin, chlordane, DDD/TDE, diel-drin, endrin, heptachlor, lindane, and toxaphene. The fate of any legislation in the Congress is to be considered uncertain until enacted by both Houses and sent to the President. H. R. 10729, the Committee rewrite of H. R. 4152, was enacted by the House in the first session of the 92nd Congress. There is strong

expectation that Senate action in the 1972 session will result in enactment of a new FIFRA very similar to H. R. 10729.

H. R. 10729 incorporates many of the provisions of the existing law (FIFRA), but goes well beyond it in the federal regulation of intrastate as well as interstate activities, including registration of pesticides in intrastate commerce. It provides for the classification of pesticides as to: (a) "general use" or (b) "restricted use." The original versions had a third category of "use by permit only." It also provides for the certification of pesticide applicators. It provides for aid and guidance to states in developing training programs for pesticide applicators and for the certification of individuals entitled to use restricted pesticides.

The bill also substantially increases the enforcement powers of the federal agency. There are provisions for criminal misdemeanor and for civil penalties. These include not only the registrant, wholesaler, dealer, retailer, or other distributor, the commercial pesticide applicator, but the farmer who "knowingly violates any provision of the Act."

Impact of the Pending Federal Legislation

A sampling of views from Congressional offices in

the five study states of Illinois, Iowa, Kansas, Minnesota, and Missouri showed: (1) the legislation was an integral part of more effective pollution control, (2) improved control of commercial and private applicators to prevent overdoses and careless applications, (3) more effective handling of pesticides, (4) reduction in on-site storage of pesticides, and (5) more effective control over retail sales subject to recall on order of the Administrator.

There seemed to be a general concurrence from farm communities on the need for legislation of this general nature. The contractor's own survey and Congressional office mail strongly express approval for passage of the legislation. The greatest opposition came from some retailers who were also applicators and some commercial applicators - both saw impending legislations as entirely too restrictive.

With respect to the potential impact of the federal legislation on state programs, each Congressional office, state Departments of Agriculture, farmers and county agents surveyed indicated the role of all state Departments of Agriculture and Agricultural Extension Service would have major responsibility.

Section 20, Research and Monitoring, and Section 23, of H. R. 10729 State Cooperation and Training, are par-

ticularly significant advances. The provisions which specifically empower the Administrator to (1) foster research in biologically integrated alternatives for pest control, (2) formulate a national plan for monitoring, (3) expand public funds to encourage state programs in training of certified pesticide applicators, are viewed by the contractor as necessary and desirable.

Testing and Registration of New Pesticides

Section 3. Registration of pesticides appears to provide for sufficient information to allow the Administrator to make adequate judgments regarding new compounds. The provisions which allow a full description of tests performed, 3 (c) (1) (D), and the results thereof to the Administrator as he desires and 3 (c) (1), wherein the Administrator shall publish guidelines specifying the kinds of information required in support of registration, are regarded as particularly important. The further provision that the Administrator shall make public all scientific information relating to the registration of any particular compound is viewed as an absolute necessity and long overdue (S 23(c) (2), p. 18, lines 4-9).

Illinois

The State of Illinois has sound laws on record

which are consistent with H. R. 10729. The provisions of the existing law are rather weak in regard to licensing of employees of pesticide applicators but compliance with the Administration bill should insure training and safety precautions. When asked about this issue, Congressman Finley's office indicated: (1) response for this bill has been favorable, (2) the bulk of the farmers and the organizations and farm cooperatives recognize the need to work within a regulatory framework in order to preclude more restrictive limitations on their use of agricultural chemicals, (3) farm cooperatives are gearing up to assist farmers through education to qualify under proposed registration systems.

Iowa

The Pesticide Act of Iowa is a combined registration (use) and applications law. Licensing provisions and enforcement need to be strengthened in Iowa. Financial responsibility for violation is more stringent in Iowa than in Illinois. The institution of a chemical technology review board in Iowa will allow the Secretary of Agriculture to promulgate additional laws and regulations.

Kansas

Stringent financial responsibility makes the Kansas Pesticide Use Law. Kansas is the only study state required to issue regulations regarding storage and safe disposal of pesticides and used containers. Although viewed as something of an intrusion on the state's own pesticide law, all the Congressmen interviewed from Kansas indicated support of H. R. 10729.

Minnesota

Minnesota's Spraying and Dusting Law was the first law in the five-state study area to employ restricted use pesticide classification. DDT and its metabolites and the cyclodienes were severely restricted as of July, 1970.

Congressman Bergland did not feel that the farmers of Minnesota have been at any disadvantage to farmers from other states because of the restrictions on the use of certain pesticides. He stated that the contacts he has had with farmers and farm organizations have at no time indicated such a disadvantage. The general tenor of comments from his home district during the period when the legislation was under consideration was favorable to passage. The only comments he has received since he

voted for the bill have been from individuals who expressed the view that legislation along the line of H. R. 10729 has been long overdue.

In total view, Minnesota already has more stringent control than most states and compares favorably with the Administration bill. No difficulty is seen in field implementation of that legislation.

It should be admitted that Minnesota does not have the same degree of agricultural involvement, as say, Iowa or Illinois, as far as corn and soybeans are concerned.

Missouri

Missouri has the weakest pesticide control law in the five-state study area. Two bills introduced in 1971 were fought strenuously by dealers and manufacturers. Public hearings were held and testimony received. Manufacturers and Applicators reported they could live with the House committee substitute for 315 and 571. Biologists and environmentalists were also satisfied. However, when brought to a vote, the bill failed to pass and both sides appeared to be surprised. At a special session (November 18, 1971), it was decided that proponents of the bill(s) would wait and see what happened to the Administration bill in the Senate (H. R. 10729).

Identity of Favorable Types of Laws

The contractor's survey of farmers, county agents, Congressional offices, pesticide applicators and retailers support the Administration bill (H. R. 10729). Although some states presently have laws which appear to control use and application, it is seen that sufficient control is not observed in practice at all times. Hopefully the provisions of the bill which would strengthen or reinforce federal aid to educational programs designed to improve methods of application and human safety would have their impact in increased environmental protection as well.

Some of the verbiage of the existing state laws is rather loose in the interpretation of how to dispose of containers and unused pesticide. Hopefully this major source of environmental contamination will be solved by more useful state laws in the future. As indicated in another section of this report, many farmers have expressed an earnest desire to dispose of their material in a suitable way but do not know of a practical solution. Aid in this matter should come from all states as soon as possible.

Assistance to farmers by way of increasing their ability to implement soil erosional control techniques

would have the multiple advantage of increasing crop yield, keeping soil loss to a minimum, and most importantly, keeping pesticides used on the land where they are normally effective. An obvious benefit would occur to farmers since annual application of certain compounds could be adjusted downward to take advantage of residue.

The strengthening of applicator laws is viewed as another very desirable feature of some laws. However, responsible operators who perform valuable services should not suffer from over-regulation.

RECOMMENDATIONS

Inventory of Pesticide Uses

1. The contractor recommends that information on the quantities of pesticides (active ingredients) used in this region should be collected and published annually. This could be done by extending the systems already initiated in the states of Minnesota and Illinois so as to include quantitative data on pesticides used, and by the establishment of similar procedures in the other states.

2. As a further source of input into the already existing and the suggested additional state systems, a

statutory requirement to report quarterly or annually the quantities of pesticide active ingredients sold to growers, might be imposed on pesticide marketers in the area.

Effects of Pesticide Application Techniques

3. The contractor would like to see a massive research effort to establish safe, effective, economical, practical solutions to the problem of empty pesticide container disposal. In the interim labels should be easily understandable so that directions can be followed under actual field conditions.

4. To help minimize contact with the toxic chemicals, plastic disposal gloves and a respirator mask, if needed, should be attached to the outside of every pesticide container holding chemicals for farm use. The user would be inclined to use safety equipment, if it were there when he picked up the package.

5. Studies of effective agricultural techniques for reducing environmental damage such as minimum tillage, grass waterways, and banding of chemicals should be made and results publicized along with an effective implementation plan.

Mechanisms of pesticide entry into the aquatic environment, the potential harm of the practices such as fall plowing should be publicized and alternative

countermeasures developed.

6. The manufacturers of pesticides have a well established system for promoting their products to the farmers. Through sales promotion the farmer is encouraged to use more, not less pesticide. This pressure the manufacturers place on farmers, on retailers, and to some extent through county agents prevents a change in use patterns from developing.

The contractor feels very strongly that a pest management program should be used, for both herbicides and insecticides to combine all agricultural practices, including selected use of pesticides on diagnosed problems such as corn rootworm in one field when it occurs, rather than a blanket application of aldrin to an entire crop at planting time. A systems approach to the pest problem could bring about a major reduction in pesticide usage without significant loss in crop yield or expense to the farmer.

The approach needed is active education of farmers to this idea, and rapid, usable advice from the state agricultural departments.

Route of Pesticides into the Water Environment

From this investigation it is clear that water contamination by pesticides will be minimized when farm field erosion is reduced. Practices such as contour

plowing and minimum tillage help slow erosion, but fall plowing and plowing to the edge of a field may produce large amounts of sediment. Several practices can reduce sediment transport of pesticides:

7. Elimination of fall plowing, which exposes broken soil to winter storms and spring run-off.

8. Leaving a barrier strip around field edges for sediment basins to catch sediment from fields. An area plowed but left unharrowed and unplanted would slow run-off and allow a portion of the sediment to settle.

9. Construction of large sedimentation basins to catch run-off from several fields, with provisions to remove sediment after each storm and return it to fields or land-banked areas for deposit.

10. Investigation of the plowing scheme; ridge plowing described by Ritter which reduced erosion and pesticide losses by a factor of seven times.

11. An extensively monitored typical basin of about 100 square miles will provide better understanding of the route of pesticides to water and their potential harm. Meteorological data, continuous flow and turbidity measurements, and sedimentation rates could be compiled with pesticide inventories and soil pesticide measurements.

If a 10 to 20 basin system could be implemented, one could more effectively evaluate the effect of pesticides in the water environment.

Impact of Pesticides On the Aquatic Environment

The contractor recommends that additional effort be expended to achieve the following:

12. Understanding of the mechanisms by which pesticide compounds are adsorbed by photosynthesizing plants is achieved.

13. Virtually a total lack of information on the cellular responses of green plants and diatoms to pesticides exists. This includes information on binding sites, specific affinities for membrane surfaces, mode of action.

14. Community structure, natural succession, growth, viability and reproduction as well as the response of photosynthetic rate to pesticide exposure for a much larger variety of aquatic plants at levels currently found in the environment as well as experimental levels is necessary.

15. There appears to be a great need for basic experimental designs which would identify not only biomagnification but long term effects which would follow reproductive success for several generations.

16. Effects of long term sub-lethal exposure on growth, reproduction and viability of a much wider variety of benthic organisms.

17. Identification of cellular routes of entry of pesticides with benthic forms.

18. Elaboration of metabolic degradation pathways of pesticide compounds in benthic animals.

19. Information of effects of chronic sub-lethal exposure to major food items of top trophic levels. These include larger crustaceans, small fish, minnows, frogs, toads, salamanders, etc.

20. Much additional information on all aspects of physiology of fish exposed to chronic sub-lethal exposures of pesticides.

21. New and expanded criteria for scientific information required of registration. These criterial should be more pertinent to impact on chronic exposure to larger varieties of non-target species.

22. Expand studies on effect of soil and water microorganisms which may degrade persistent compounds and which may themselves be effected in such a way as to not perform their ecological function as we now know it.

23. Much additional information required on rates of excretion and particularly differential turn-over

rates between different animal groups.

24. Model ecosystems probably have lower values in predicting the fate of certain compounds. Such modeling should be continued with trophic dynamic considerations and attempts at balance equations.

25. Although models have their place, there is no substitute for field studies. These should be expanded to include more in-depth studies of specific watershed and basins and a much wider variety of aquatic ecosystems.

26. Expanded programs to identify the potential for harm to humans from both chlorinated hydrocarbons and organo-phosphates. State support should be solicited.

27. Expanded educational efforts on use and application as well as health hazards involved.

28. Industrial support is needed to develop safer compounds; this may include new technology aimed at safer handling practices and formulations.

29. Agricultural engineering might provide new and innovative methodology for application of pesticides.

Degradation of Pesticides in the Environment

30. We recommend that a massive, interdisciplinary research effort be mounted to clarify the environ-

mental behavior of major pesticides which are expected to continue in use for the foreseeable future. Information needed includes their fate in the environment after application; routes of metabolism, degradation and disappearance; nature of the ultimate breakdown products; effects of long-term exposure of ecosystems to low-level residues; and interactions with other chemicals in the environment. It will be necessary to establish an order or priority among products to be thoroughly investigated in this fashion.

31. We recommend that the responsibility to establish such a priority system and to plan, spearhead and oversee the research program itself be assigned to a specific office or committee within the EPA.

32. We further recommend that actual performance of the research work required should not be limited to tax-supported agencies, but that all possible research capabilities should be mobilized including those of industry, independent and non-profit research organizations, etc. By and large, industrial and independent research organizations have more experience and have had more success in the management and performance of truly interdisciplinary research than government or university laboratories. This type of experience is greatly needed

in this extremely complex area of environmental research.

Alternatives to Chemical Control of Weeds and Insects

33. The contractor recommends that a concerted effort be undertaken to reduce or eliminate the prophylactic use of insecticides, especially chlorinated hydrocarbons, for the control of the "soil insect complex" on corn. Growers should be strongly encouraged to leave entire fields or portions thereof untreated and/or to use insecticides at reduced rates, to establish to what extent, if any, prophylactic insecticide treatments are needed for this purpose. As an alternative or additive measure, establishment of an insurance system similar to hail insurance, coupled with a ban on the prophylactic use of chlorinated hydrocarbon insecticides, should be investigated.

34. The contractor further recommends that the development of a practical, realistic "pest management" system for soybeans receive all necessary research administrative and organizational attention. The present state of affairs where this important crop is not yet subject to routine insecticide treatments offers a unique opportunity to develop all aspects of a sound insect management system for the bottom-up, unincumbered by pre-existing pesticide use patterns, vested interests, etc.

Applicable Laws and Regulations

35. The contractor, throughout surveys and interviews, found general support for the Administration Bill (H. R. 10729).

36. Licensing provisions of H. R. 10729 appear adequate provided sufficient valid support of claims is presented. This would include updated standards, especially in the area of chronic sub-lethal exposure. Rising costs dictate that new products should not be unduly restricted where no imminent harm to humans or, more important, to the total ecosystem is presented.

37. Compounds which are known to rapidly hydrolyze or otherwise decompose in the environment should be given considerably more latitude than compounds which are specifically identified as persistent.

38. The contractor believes that there are some applications of some persistent pesticides which may be tolerated on a prescriptions dispensing basis for structural pest users and other uses which show none, or very little likelihood of environmental contamination. In any event, the amounts used should be rigidly controlled and even these uses should be phased out as soon as compounds with more desirable characteristics are found. We should strive to achieve integrated methods and control which would specifically identify the need

for use of these compounds only when needed and in the amounts needed.

39. It is clear that some kind of licensing is required of pesticide applicators. Federal and state sponsorship of training requisites to licensing is encouraged as is a rigid enforcement program.

40. Catalytic thermal decomposition of unused pesticides and empty pesticide containers is not possible by the average farm user. Clearly, state or Federal implementation is required to dispose of unused or surplus pesticides. Manufacturers directions are not practical. Dumping or burning as presently practiced are clearly inadequate. The single biggest complaint from farmers was that no one has provided sufficient information for safe disposal.

41. The likelihood of increased human exposure is enhanced with increased pesticide use. Statewide implementation plans, such as those in Kansas and Iowa, which alert medical doctors to the possibility of harm, is a helpful measure and should be encouraged. Prescribed safety methods, including the wearing of plastic garments and gloves or respirators, appear to be largely ignored. The contractor thus recommends that additional steps be taken by manufacturers to product formulations which are more dust-free, covered with a protective

coating which could dissolve when wetted, or such other plans which would reduce the likelihood of human exposure.

42. It is recommended that considerably more effort be expended in the area of controlled degradation and self-destruct methodology.

43. Standardization of leak-proof, safe container is absolutely essential. The manufacturer who packages in a desirable container and then tells the farmer to destroy it is obviously unaware of the inherent thrift of most farmers. Self-punching boxes and cans which do not require additional handling by the operator have been suggested. The payment of demurrage or a premium on returned containers is also a possible solution.

44. Additional research is badly needed in methods of adequate disposal of used pesticide containers.

45. It is recommended that stronger effluent requirements be instituted and enforced against pesticide manufacturers and formulators.

46. The contractor recommends integrated research programs as well as a streamlined registration procedure. This will enhance cooperation between scientists and generally insure that adequate information is gathered openly to assure maximum environmental protection with due regard to the interests of pesticide companies.

TABLE
FACTORS WHICH LIMIT FARMERS USE OF PESTICIDES

Factor	Illinois	Iowa	Kansas	Minnesota	Missouri	Total
Cost	69%	66%	35%	60%	64%	72%
Availability	--	6	9	5	3	5
Ease of application	19	22	11	12	20	18
Dangerous to use	21	32	51	17	22	29
Fear of environmental damage	21	34	35	27	40	30
Other, unspecified (little need, "carry-over", etc.)	10	11	16	13	17	14
Total Contacts	52	98	57	60	55	

NOTE: Percentages do not add to 100% since many farmers made multiple entries.
All figures rounded off to nearest whole number.

TABLE
 OPINIONS OF AGENTS AND FARMERS AS TO WHETHER
 PESTICIDES ARE REQUIRED TO INSURE GOOD CROP YIELD

Source	Illinois	Iowa	Kansas	Minnesota	Missouri
Agents Response ¹					
Yes	91%	97%	88%	81%	100%
No	9	3	12	19	--
Farmers Response ²					
Yes	80	81	78	68	89
No	20	19	22	32	11

¹Totals from 176 county agents uniformly distributed over five study states.

²Totals from 331 independent farmers uniformly distributed over five study states.

TABLE
EXTENT OF USE OF ALTERNATE METHODS OF INSECT AND
WEED CONTROL IN FIVE STUDY STATES ASKED OF AGENTS

	Illinois	Iowa	Kansas	Minnesota	Missouri
Specific Method Used					
Yes	21	23	30	21	15
No	15	12	7	16	7
Methods					
Cultivation	G	G	?	G	G
Biological* (includes Parasites and Bacteriological)	P	F	F	P	G-VP
Rotation	G	G	G	G	G

G = Good success where used

F = Fair success where used

P = Poor result where used

VP = Very Poor

? = Questionable results . . . difficult to assess

*Responses noted are from very few isolated agents comments.

TABLE
COUNTY AGENTS RESPONSE TO OBJECTIVE EVIDENCE BY
MANUFACTURERS FROM TEST OR YIELD PLOTS

	State ¹				
	Illinois (45)	Iowa (47)	Kansas (41)	Minnesota (44)	Missouri (37)
Objective Evidence					
Yes	22	14	17	21	15
No	23	18	19	23	18
Company					
Geigy	8 ²	8	8	7	4
Monsanto	5	5			3
Stauffer	2				
Elanco		1	1		
Shell	1	1			
Niagra	2				
Cyanamide	1	2			
Kaiser	1				
Arco		1			
Lily					1
POW					1

¹Number in parentheses indicates number of agents responding from each state.

²Number equals number of test plots or yield con-
tests known to agricultural agents by company.

IS ANYONE IN YOUR AREA TRYING
AN ALTERNATE METHOD OF CONTROL?

REPLIES OF THE FARM AGENTS

ILLINOIS

- We have one organic farmer
- Alternating corn and soybeans.
- A hammer and a block of wood are slow.
- Yes, with total failure.
- "Old fashioned" farmers use cultivation instead.
- Has been work done by University of Illinois on alfalfa weevil control-parasite.
- It doesn't work.
- Rotation of crops and other management practices have long been used as an alternative to chemicals. Pesticides fill the gap when others fail.

IOWA

- For insect control, yes, not in weed control so much.
- A few organic farmers. Some rotate to control corn rootworms.
- Bacillus Thuringiensis for corn bore control.
- Alternating corn and soybeans to control corn rootworm.
- Some still depend only on cultivation.
- Some do but yields generally show it.

KANSAS

- Only rotation where possible.
- There have been attempts to control greenbugs in grain sorghum with lady beetles - effect is too little, too slow and unpredictable.
- Biological control is stressed where practiced by the extension service. It is not practiced in most cases, however.
- Yes, but not doing well with them.

- We (extension service) encourage farmers to allow natural control whenever possible. An example would be control of aphid or greenbugs by predators.
- Rotation.
- Only through extension channels.
- Of course, cultivation is still used for weed control, but as a supplement to chemicals. Also, disease and insect resistant varieties are used.

MINNESOTA

- Yes, several are using a Wonderlife product, which failed miserably in our area this year on Weevil Control. Those using have only half a crop.
- The ones with no control have suffered extensive losses.
- Majority of farmers are using crop rotation and cultural methods.
- A few organic enthusiasts.
- We have a few organic people who have ideas of control, but on this amount of acreage it proves nothing.
- We have a few "Organic" farmers that are moving in, but they soon get over that idea.
- Cultivation and rotation are the only alternate practices.
- Some have and failed.
- No, no practical alternatives except crop rotation.
- Flame cultivation
- Some have gone to cultivating again, but I don't think that they had as much success as they had hoped for.

MISSOURI

- Practically all farmers practice some type of rotation, but not on all fields. This actually helps some insects.
- No alternate methods of control are being used except for crop rotation.
- Few farmers use rotation; they use it unknowingly.
- On some of the smaller farms they are cultivating crops as a means of weed control, but this is an old method and farmers using it simply have not progressed.

- Rotation of crops is not used as much as previously, but it still is used for insect and disease control when pesticides don't work.
- Ladybugs have taken care of aphid problems on milo.
- Yes, but failing miserably.
- Cultivation for weeds.
- What alternate method is there? Rotation, yes.
- Yes, farmers always have. Demand for better products and cost price squeeze necessitate its use.
- Yes, most farmers are using pesticides on a "have to" basis as much as possible.

ARE PESTICIDES REQUIRED TO INSURE A GOOD CROP YIELD?

REPLIES OF THE FARM AGENTS

ILLINOIS

- Not all the time.
- No, but they are beginning to worry about corn bore.
- Yes, against the corn root worms.
- They are forced to due to pure economics.
- They know it!

IOWA

- The majority do on specific crops when specific problems are present.
- Yes, they must.
- Yes, for corn rootworm control especially.
- Many do but not all.

KANSAS

- Without pesticides 60% of our farmers would cease operations - no profit.
- More progressive farmers do.
- No, you can still get a good yield without using pesticides.
- Not necessarily, they use it as a last resource.
- Most do; thus, tending to spray before needed at times.
- In many years, yes, especially in our corn fields.
- Most use crop insecticides as a last resort.

MINNESOTA

- No, pesticides cost money, therefore, are used to counteract a problem.

- Especially corn rootworm control.
- In our area it is not totally necessary.
- Certain pesticides use is generally considered necessary.
- Only a portion feel so.
- Herbicides, yes, and potato insecticides.
- Only on second year corn is it a must situation.
- Absolutely, they can't do the job without.

MISSOURI

- Yes, during certain times when weather favors pests.
- Insecticides are too costly to use unless severe epidemic of bugs is expected.
- Pesticides are a "tool of production."

APPENDIX B

INVENTORY OF PESTICIDE USES

Selection of Study Area

The use of pesticides on important midwestern farm crops in relation to total U. S. agricultural pesticide use is as follows (1):

Herbicides:

Corn	46 million pounds of active ingredient or 41 percent of total U. S. farm use
Soybeans	10.4 million pounds of active ingredient or 9 percent of total U. S. farm use
Wheat	8.2 million pounds of active ingredient or 7 percent of total U. S. farm use

Thus, the above three crops account for more than 50 percent of total farm use of herbicides in the U. S.

Insecticides:

Corn	23.6 million pounds of active ingredient or 17 percent of total U. S. farm use
------	--

Soybeans 3.2 million pounds of active ingredient or 2 percent of total U. S. farm use

Use of insecticides on soybeans is small, and even smaller amounts of insecticides are used on wheat and other small grains. Corn receives by far the largest amounts of insecticides among the midwestern field crops.

Fungicides:

There is no distinct major use of fungicides on midwestern farm crops. Total U. S. use of fungicides (exclusive of sulfur) in 1966 amounted to approximately 31 million pounds, used on a variety of different crops in all parts of the country. Heaviest uses are on fruit and vegetable crops.

Other Pesticides:

There are no distinct major uses of other pesticides on midwestern farm crops

The foregoing analysis of pesticide uses on major midwestern field crops led us to focus this study on the use of herbicides on corn, soybeans and wheat, and on the use of insecticides on corn.

The leading corn producing states are Illinois, Iowa, Indiana and Minnesota (2). The leading soybean producing states are Illinois, Iowa, Arkansas and Missouri.

The leading wheat producing state is Kansas. This geographical distribution pattern of corn, soybeans and wheat prompted us to select the states of Minnesota, Iowa, Illinois, Missouri and Kansas for an intensive study of the problems outlined in the introduction.

Description of the Five State Area

Geographically, the five state area extends from 87.5° (Eastern border of Illinois) to 102° (Western border of Kansas) western longitude, and from 36° (Missouri bootheel) to 49° (Northern border of Minnesota) northern latitude. Naturally, such a considerable spread encompasses considerable variation in climatic, soil and other environmental conditions. These in turn account for some important differences in general agricultural practices and, more specifically, in pest problems and pesticide use patterns. On the other hand, some growing practices and pesticide use patterns are remarkably similar for a given crop over the entire five state area.

Table 1-B summarizes for the five states the major crops grown, total crop acreage, and total land area (2, 3, 4, 5, 6, 7, 8). The total acreage of each crop is compared to the U. S. total. The five states

TABLE 1-B
LAND USE AND MAJOR FIELD CROPS GROWN IN THE 5-STATE AREA
(In 000 Acres)

State	Major Crops Grown						All Other Crops	Total Crop Acreage	Total Land Area	Crop Acreage % of Total Land Area
	Corn	Soybeans	Wheat	Oats	Sorghum	Hay				
Minnesota	5,285	3,129	830	3,354	negl.	3,231	1,671	17,500	50,745	34
Iowa	10,072	5,389	negl.	1,817	negl.	2,496	negl.	19,931	35,868	56
Illinois	10,379	6,865	993	612	negl.	1,260	303	20,412	35,761	57
Missouri	3,114	3,557	1,059	312	298	3,008	negl.	11,400	44,190	26
Kansas	1,637	1,005	9,061	250	4,277	2,384	494	19,108	52,516	36
5 States	30,487	19,945	11,943	6,345	4,575	12,379	2,464	88,351	219,080	40
U.S.	67,171	43,332	47,000	24,312	17,292	63,234	77,659	340,000	2,266,273	15
5 States/ U.S.	45%	46%	25%	26%	26%	20%	3%	26%	9.7	

Note: Data in this tabulation originate from several different sources (including 2, 3, 4, 5, 6, 7, 8), and some items are not expressed numerically. For these reasons some columns do not balance arithmetically.

account for 45 percent of the total U. S. corn acreage, 46 percent of soybeans, 25 percent of wheat, 26 percent of oats and sorghum, respectively, and 20 percent of hay. The five states comprise only 9.7 percent of the total U. S. land area, but 26 percent of total U. S. crop acreage. Of the total land area in the five states (220 million acres), 40 percent or 88 million acres were planted to field crops. The ratio of total crop acreage to total land area varies from 26 percent for Missouri to 56 to 57 percent for Iowa and Illinois, respectively. In the U. S. as a whole, total crop acreage represents only 15 percent of total land area. Thus, the five state area selected for this study is one of the more intensely farmed land areas of the U. S.

Pesticide Use in the Five State Area

Tables 2-B, 3-B, and 4-B summarize the estimated uses of herbicides and insecticides in the five state area on corn, soybeans and small grains, respectively.

Tables 5-B through 8-B summarize the estimated total number of acres treated by state, type of treatment, major individual pesticide products, and approximate total quantities used for corn herbicides (Table 5-B) soybean herbicides (Table 6-B), small grain herbicides (Table 7-B) and corn insecticides (Table 8-B). Table 9-B

TABLE 2-B
ESTIMATED USE OF HERBICIDES AND INSECTICIDES ON CORN IN THE 5-STATE AREA

State	Total Acres Grown (000)	Herbicide Treatments				Insecticide Treatments			
		Area Treated Acres ¹ (000)	% of Acres Grown	Pre-Emergence		Area Treated Acres ¹ (000)	% of Acres Grown	Pre-Emergence	
				Acres ² (000)	% of Acres Treated			Acres ² (000)	% of Acres Treated
Minnesota	5,285	4,144	78	2,814	68	1,112	21	1,067	96
Iowa	10,072	6,000	60	4,500	75	6,500	65	6,500	100
Illinois	10,379	8,324	80	7,000	67	5,702	55	5,800	100+
Missouri	3,114	2,500	80	1,750	70	2,020	65	2,000	100
Kansas	1,637	1,230	75	1,050	85	650	40	575	88
5 States	30,487	22,198	73	17,114	77	15,984	52	15,942	100
				11,362	51			2,913	18

¹Net acres (acres treated one or more times).

²Gross acres (acres treated more than once counted for each treatment).

TABLE 3-B
ESTIMATED USE OF HERBICIDES AND INSECTICIDES ON SOYBEANS IN THE 5-STATE AREA

State	Total Acres Grown (000)	Herbicide Treatments		Insecticide Treatments		Remarks
		Area Treated Acres (000)	% of acres grown	Area Treated Acres (000)	% of acres grown	
Minnesota	3,129	1,932	62	less than 1%		
Iowa	5,389	4,000	75	75	1.4	
Illinois	6,865	4,900	71	130	2	
Missouri	3,557	2,700	75	negligible		Up from 42,000 acres treated in 1969
Kansas	1,005	550	55	less than 1%		
5 States	19,945	14,082	70.5	250	1.25	

TABLE 4-B

ESTIMATED USE OF HERBICIDES AND INSECTICIDES ON SMALL GRAINS¹ IN THE 5-STATE AREA

State	Total Acres Grown (000)	Herbicide Treatments		Insecticide Treatments	
		Area Treated Acres (000)	% of acres grown	Area Treated Acres (000)	% of acres grown
Minnesota	4,866	2,732	56	less than 1%	
Iowa	1,817	550	30	negligible	
Illinois	1,645	45	27	less than 1%	
Missouri	1,371	550	40	negligible	
Kansas	9,311	4,650	50	900	10%
5 States	19,010	8,527	45	950	5%

¹"Small grains" = primarily oats in Minnesota and Iowa; primarily wheat in Missouri and Kansas; about 2/3 wheat and 1/3 oats in Illinois.

TABLE 5-B
CORN HERBICIDES

ESTIMATED NUMBER OF ACRES TREATED, BY STATE, TYPE OF TREATMENT,
MAJOR PRODUCTS, AND TOTAL QUANTITIES, 1971

State	Type of Treatment	Major Products, Acres (000) Treated ²								all pre-em. herbicides ² (000 acres)	all post-em. herbicides ² (000 acres)	all herbicides ¹ (000 acres)
		atrazine-pre	atrazine-post	propachlor/atrazine	propachlor	alachlor	2,4-D-type-pre	2,4-D-type-post	minor quantities of all other products			
Minnesota	pre-em.	863	--	307	1,432	144	--	--	2,814	2,814	2,762	4,144
Iowa	post-em.	--	1,374	--	--	--	--	1,269	--	--	--	--
	pre-em.	2,300	--	--	700	900	--	--	4,500	4,500	4,500	6,000
Illinois	post-em.	--	2,250	--	--	--	--	2,250	--	--	--	--
	pre-em.	2,240	--	605	2,067	285	550	--	7,000	7,000	2,800	8,324
Missouri	post-em.	--	728	--	--	--	--	--	1,753	1,750	1,000	2,500
	pre-em.	1,000	--	--	260	260	--	600	--	--	--	--
Kansas	post-em.	--	300	--	--	--	--	--	1,050	1,050	300	1,230
	pre-em.	800	--	--	--	150	--	--	--	--	--	--
Total acres Treated	post-em.	--	120	--	--	--	--	120	2,849	17,114	11,362	22,198
	pre-em.	7,203	4,772	912	4,459	1,739	550	5,992	2,849	17,114	11,362	22,198
Avg. rate, lbs. active/acre Total herbicide quantities, 000 lbs. a.i.		11,975	4,772	912	4,459	1,739	550	5,992	2,849	17,114	11,362	22,198
		2.4	11.975	3/1.3	3.6	2.5	1.5	0.5	number of different products	11,362	11,362	22,198
		28,800	28,800	2,700 (propachlor)	16,000	4,350	825	3,000	minor quantities of all other products	11,362	11,362	22,198
		1,200	1,200	1,200 (atrazine)	2,700	4,350	825	3,000	minor quantities of all other products	11,362	11,362	22,198

¹Net acres (acres treated one or more times)

²Gross acres (acres treated more than once counted for each treatment).

TABLE 6-B
SOYBEAN HERBICIDES

ESTIMATED NUMBER OF ACRES TREATED, BY STATE,
MAJOR PRODUCTS, AND TOTAL QUANTITIES, 1971

State	Major Products, Acres (000) Treated				all herbicides (000) acres
	alachlor	amiben	trifluralin	all other products	
Minnesota	330	1,199	349	minor quantities of a number of different products	1,932
Iowa	800	800	2,000		4,000
Illinois	446	2,553	1,049		4,900
Missouri	1,100	700	400		2,700
Kansas	170	170	170		550
Total acres (000) Treated	2,846	5,422	3,968	1,846	14,082
Avg. rate, lbs. act./ acre	2.5	2.5	1.0		
Total herbi- cide quanti- ties, 000 lbs. active ingredient	7,100	13,600	3,970		

TABLE 7-B
SMALL GRAIN HERBICIDES

ESTIMATED NUMBER OF ACRES TREATED, BY STATE,
MAJOR PRODUCTS AND TOTAL QUANTITIES, 1971

State	Major Products Acres (000) Treated		all herbicides (000 acres)
	phenoxy-type	other herbicides	
Minnesota	2,729	negl.	2,732
Iowa	545	negl.	550
Illinois	45	negl.	45
Missouri	545	negl.	550
Kansas	4,250	400	4,650
Total acres (000) Treated	8,114	413	8,527
Avg. rate, lbs. Active/Acre	0.4		
Total herbicide quantities, 000 lbs. active ingredient	3,200		

TABLE 8-B
CORN INSECTICIDES
ESTIMATED NUMBER OF ACRES TREATED, BY STATE, TYPE OF TREATMENT,
MAJOR PRODUCTS, AND TOTAL QUANTITIES, 1971

State	Type of Treatment	Major Products, Acres (000) Treated ²										all pre-em. insecticides ² (000 acres)	all post-em. insecticides ² (000 acres)	all insecticides ¹ (000 acres)
		aldrin	bux	diazinon pre-em.	diazinon post-em.	phorate pre-em.	phorate post-em.	DDT	heptachlor	toxaphene	parathion	carbaryl		
Minnesota	pre-em.	248	390	92	18	167	40		17				1,067	1,112
Iowa	post-em.				negl.	875			240	950		550	6,500	6,500
	pre-em.	2,700	1,750		350			100					2,000	2,000
Illinois	post-em.	2,600	841	146	56	853	39		654				5,800	5,702
Missouri	pre-em.					140			420				2,000	2,020
	post-em.	1,300	140		negligible									
Kansas	pre-em.	negl.	190			200	50				160	50	575	650
Total acres Treated	post-em.													
		6,848	3,311	238	424	2,235	129	100	1,331	950	160	600	15,942	15,984
Avg. rate, lbs active/acre				662	662	2,364	2,364	2.0	2.0	2.1	0.5	2.0		
		1.6	0.85	1.0	1.0	1.0	1.0							
Total insecticide quantities, 000 lbs. active ingredient		11,000	2,800	662		2,364		200	2,660	2,000	80	1,200		

¹Net acres (acres treated once or more times).

²Gross acres (acres treated more than once counted for each treatment).

TABLE
ESTIMATED QUANTITIES OF MAJOR PESTICIDES USED IN THE 5-STATE AREA ON
CORN, SOYBEANS AND SMALL GRAINS
1971

	Pesticide	Crop	MM lbs of Active Ingredient
Herbicides:	atrazine	corn	30,000
	propachlor	corn	18,700
	amiben	soybeans	13,600
	alachlor	soybeans	11,450
		7,100)	
		4,350}	
	2,4-D - type	corn	7,025
		3,825)	
		small grains	3,970
	trifluralin	soybeans	
Insecticides:		corn	11,000
	aldrin	corn	2,800
	Bux	corn	2,660
	heptachlor	corn	2,364
	phorate	corn	2,000
	toxaphene	corn	1,200
	carbaryl	corn	662
	diazinon	corn	200
	DDT	corn	80
	parathion	corn	

summarizes the estimated total quantities of the major herbicides and insecticides used in the five state area.

Until recently, reliable information on the quantities of specific pesticides used by crops or by states was practically unavailable to the public. Several commercial market survey organizations specialize in collecting this type of data and offer it for sale. In addition, most, if not all of the major pesticide manufacturers have their own market intelligence organizations and systems. Thus, each of these groups have their own estimates of the total volume and distribution patterns of pesticides, but this information is closely guarded and generally not accessible to scientists, regulatory officials and policy makers in the public domain.

In response to the increasing concern about possible environmental damage from the use of pesticides, several states have initiated procedures to collect pesticide use data within the last few years. Among these, California probably has the best and most advanced system. In our five state area, Minnesota and Illinois, which belong to the five Great Lakes States, began in 1969 to gather information along these lines. The governors of the states of Illinois, Indiana, Michigan, Minnesota and Wisconsin met in April of 1969 to review the pesti-

cide situation in regard to possible environmental pollution. Following this conference, the governors instructed the agricultural statisticians in their respective states to collect and publish annually statistical data on the use of pesticides on farms. The second annual survey was made in 1970. The data from this survey were used for the states of Minnesota and Illinois (9, 10) in compiling Tables 2-B through 9-B.

While these state publications certainly represent a great improvement over the previous condition of a complete lack of pesticide use data, they still leave many questions unanswered. For instance, the states report pesticide use only in terms of numbers of acres treated, but not in terms of quantities of specific pesticides applied. There are tables on rates of application, but it is not clear whether these refer to active ingredients or to formulation, and the rates given are sometimes considerably at variance with those recommended by the manufacturers and the state extension services (11, 12, 13, 14). As a result, we still had to use considerable extrapolating and guessing in compiling the inventory of pesticide uses, even for the states of Minnesota and Illinois.

The states of Iowa, Missouri and Kansas do not collect or publish similar statistics on the use of pesti-

cides. Pesticide use estimates for these states were made by way of personal consultation with the state extension entomologists and weed control specialists in each state, supplemented by the results of the field survey of pesticide retailers, county agents and individual farmers. State Extension Service use recommendations for pesticides (15, 16, 17, 18, 19, 20, 21), the "1971 Weed Control Manual" (22) and manufacturers' label recommendations were also consulted.

It must be emphasized that in spite of a great amount of effort spent in preparing these pesticide use estimates for the five states, these are probably not as accurate as would be desirable. It must also be emphasized that Tables 2-3 through 9-B are composed of elements of different origin and different reliability. However, we believe that our findings and recommendations, insofar as they refer to these data, are still valid because they are based on scope of magnitude-type considerations for which great accuracy is desirable but not essential.

Pest Problems in Relation to Pesticide Use

A more detailed discussion of weed, insect and disease problems on major crops in the five states is included in Appendix G, "Alternatives to Chemical Con-

trol", because it is essential to a meaningful treatment of that topic. The following more general comments are pertinent in the context of this section.

By and large, weed problems on corn, soybeans and wheat, and the percentage of acres treated in each state vary within only relatively narrow ranges. Of the approximately 30 million acres of corn grown in the five state area (Tables 2-B, 5-B), 73 percent or about 22 million acres received herbicide treatments. The ratio of acres treated to total acres of corn grown varied from a low of 60 percent in Iowa to a high of 80 percent in Illinois and Missouri. Seventy-seven percent of all acres treated with herbicides received pre-emergence treatments, 51 percent received post-emergence treatments. A considerable number of acres received more than one treatment. Therefore, the percentage totals exceed 100, and the sum of "gross acres" treated pre-emergence and post-emergence, respectively, exceeds the number of total "net acres" treated.

Of the almost 20 million acres of soybeans grown in the five states (Tables 3-B, 6-B), 70.5 percent or about 14 million acres received herbicide treatments. The ratio of acres treated to total acres of soybeans grown varied from a low of 55 percent for Kansas to a high of

75 percent for Iowa and Missouri. Almost all soybean herbicides are applied pre-emergence; therefore, no separation between pre- and post-emergence herbicide treatments has been made for this crop.

Of approximately 19 million acres of small grains grown in the five states (Tables 4-B, 7-B), 45 percent or about 8.5 million acres received herbicide treatments. Ratio of acres treated to total acres of small grains grown varied from a low of 30 percent for Iowa to a high of 56 percent for Minnesota, with the exception of a reported figure of only 2.7 percent (45,000 acres out of 1.6 million) of total acreage treated for the state of Illinois (10). This low figure for Illinois is so completely out of line with the figures for the other four states that we question its validity and tend to believe that in reality, a higher percentage of Illinois small grain acres receive herbicide applications, more nearly in line with the situation in the other four states. Almost all small grain herbicides in this area are applied post-emergence. Therefore, no separation between pre- and post-emergence treatments has been made in Table 4-B.

Insect problems and acreage treated for insect control vary more widely within the five state area. Approximately one-half of all corn acres in the five states (Tables 2-B, 8-B) received insecticide treatments.

The ratio of acres treated to total acres of corn grown varied from 21 percent in Minnesota to 65 percent in Iowa and Missouri. Some corn acres were treated with insecticides more than once. As in the case of herbicide treatments on corn, this is the reason why the percentage of treated acres exceed 100, and why the combined "gross acres" for pre- and post-emergence insecticide treatments exceed the numbers of "net acres" treated.

About 2 million acres of corn in Iowa received post-emergence insecticide treatments, primarily against corn borers and cutworms. Insecticides used for this purpose include an estimated 100 to 200,000 pounds of DDT. By contrast, Illinois reported only 286,000 acres of corn treated with post-emergence insecticides, and the products used did not include chlorinated hydrocarbons. These apparent differences are surprising, but in assessing them, it must be remembered that the Illinois data come from the official state statistics (10), whereas the collection of the Iowa data had to rely heavily on personal interviews and field contacts. We are inclined to believe that in Illinois, perhaps some corn acres treated with post-emergence insecticides escaped the official survey, but emphasize that this is just a suggestion, not backed up by hard facts.

The use of insecticides on soybeans (Table 3-B) is

rather small; only 1.25 percent (250,000 acres) of the approximately 20 million acres grown received insecticide treatments. Slightly more than one-half of these, or 130,000 acres, were in the state of Illinois. It is important to note that this represents a large increase (more than 200 percent) in comparison to the 42,000 acres treated for insect control in Illinois in 1969. Many entomologists predict a large increase in the use of chemical insecticides on soybeans in the years to come.

Of the approximately 19 million acres of small grains grown, 950,000 or about 5 percent received insecticide treatments (Table 4-B). Almost all of this treated acreage is located within the state of Kansas.

Table 9 summarizes the total quantities of 6 major herbicides and 9 major insecticides which comprise the great majority, probably well above 90 percent of all agricultural pesticides used in the five states. Before these estimates were finalized, they were checked for plausibility against the most recent national pesticide statistics (23, 24) and also against the only breakdown of agricultural pesticide uses thus far published by the U. S. Department of Agriculture (1), although the latter is now five years old.

Atrazine is used in far greater quantities than

any other pesticide. The use of propachlor is declining, a development reportedly encouraged by its manufacturer who pushes another product, alachlor, instead. The use volumes of amiben, trifluralin and the phenoxy-type herbicides appear to be fairly level.

Among the insecticides, aldrin still dominates the scene. A substantial decline in its volume has been predicted for years, but seems to materialize only very slowly, despite increasing corn rootworm resistance and regulatory restrictions. Other chlorinated hydrocarbon insecticides which were used in substantial quantities include heptachlor and toxaphene, and even some DDT.

Use of organic phosphate and carbamate insecticides is expected to increase.

Summary and Conclusions

The five midwestern states selected for this study comprise only 15 percent of the total U. S. land area, but 40 percent of the total U. S. crop acreage (Table 1-B). There are about 88 million acres of farm crops (including hay) grown in these five states. Corn, soybeans, small grains and sorghum combined account for about 73 million acres, or 83 percent of total farm crop acreage in the five states. The balance consists of hay (12 million acres) and some minor crops. Thus,

this region is intensively farmed. A high percentage of its total land area is devoted to the growing of crops. Five field crops dominate the scene.

There are no publicly available sources of information on the quantities of pesticides used in these states. Minnesota and Illinois collect and publish annually information on the number of acres of different crops treated with specific pesticides, but do not include in their statistics information on the total quantities of pesticides used. The other three states do not collect or publish any state-wide pesticide use data at all. Our estimates of the amounts of major herbicides and insecticides used, broken down by states, crops and type of treatment, are summarized in Tables 5-B to 9-B. There are no major fungicide uses in this area.

To the best of our knowledge, such quantitative data on the pesticides used on major farm crops in this region have not heretofore been available. However, this type of information is needed by scientists, regulatory officials, legislators and others for an intelligent and continuous assessment of the actual and potential impact of pesticides on the environment in the region; for pinpointing problems requiring research, regulatory or other actions; for the establishment of priorities in research and in monitoring programs; and for many

other purposes. The present situation where this information is available only to a small group of commercial interests on a privileged basis seems to be rather incongruous with the public "need to know". We discussed this problem with many of the major basic manufacturers of pesticides. A great majority of them agreed that publication of pesticide use data would not harm their interests if it were a requirement imposed and enforced equitably on all manufacturers. The fact that the California system (25), which reports pesticide uses by individual products, and by quantities, appears to be universally welcomed and used by all public and private groups concerned with pesticides confirms this view.

Recommendations

We recommend that information on the quantities of pesticides (active ingredients) used in this region should be collected and published annually. This could be done by extending the systems already initiated in the states of Minnesota and Illinois so as to include quantitative data on pesticides used, and by the establishment of similar procedures in the other states. Alternatively, or as a further source of input into the already existing and the suggested additional state sys-

tems, a statutory requirement to report quarterly or annually the quantities of pesticide active ingredients sold to growers, might be imposed on pesticide marketers in the area.

LITERATURE REFERENCES

- 1 "Quantities of Pesticides Used by Farmers in 1966,"
Agricultural Economic Report No. 175, Economic
Research Service, U. S. Department of Agriculture,
Washington, D. C., 1970.
- 2 Agricultural Statistics 1970, U. S. Department of
Agriculture, Washington, D. C., 1970.
- 3 Minnesota Agricultural Statistics 1971, Minnesota
Department of Agriculture and State-Federal Crop
and Livestock Reporting Service, March 1971.
- 4 Iowa Annual Farm Census 1969, Bulletin No. 92-AE,
Iowa Department of Agriculture and U. S. Depart-
ment of Agriculture, Des Moines, Iowa, 1970.
- 5 Iowa Book of Agriculture 1968-1969, Iowa State
Department of Agriculture, Des Moines, 1970.
- 6 Illinois Agricultural Statistics/Annual Summary
1971, Illinois Cooperative Crop Reporting Service,
Illinois Department of Agriculture and U. S. De-
partment of Agriculture, Bulletin 71-1, 1971.
- 7 Missouri Farm Facts 1971, Missouri Crop and Live-
stock Reporting Service, Columbia, Missouri, 1971.
- 8 Farm Facts 1970/1971, Kansas Crop and Livestock
Information for 1970 and Preliminary Estimates
for 1971, Kansas State Board of Agriculture,
Topeka, 1971.
- 9 General Farm Use of Pesticides 1970, Minnesota and
Four Other Great Lakes States, Minnesota Depart-
ment of Agriculture and State-Federal Crop and
Livestock Reporting Service, 1971.
- 10 Illinois Agricultural Statistics/Pesticide Use by
Illinois Farmers, 1970, Illinois Cooperative Crop
Reporting Service, Illinois Department of Agricul-
ture and U. S. Department of Agriculture, Bulletin
71-3, 1971.
- 11 "Cultural and Chemical Weed Control in Field Crops
1971", Extension Folder 212-Revised, Agricultural
Extension Service, University of Minnesota, 1971.

- 12 "Insecticides and Their Uses in Minnesota 1971",
Extension Bulletin 263 - Revised, Agricultural
Extension Service, University of Minnesota, 1971.
- 13 1971 Suggested Insecticide Guides/Insect Control
for Field Crops, University of Illinois at Urbana-
Champaign, College of Agriculture, Cooperative
Extension Service, In Cooperation with Illinois
Natural History Survey, Circular 899, Urbana,
Illinois, 1970.
- 14 1971 Weed Control Guide, from Illinois Agronomy
Handbook for 1971, Cooperative Extension Service,
University of Illinois at Urbana-Champaign, 1971,
pp. 1-12.
- 15 Weed Control Series, Iowa State University of Sci-
ence and Technology, Cooperative Extension Service,
Ames, Iowa, Pm-371 (Rev.), Feb., 1969.
- 16 Summary of Iowa Pest Control Recommendations for
1971, Cooperative Extension Service, Iowa State
University, Ames, IC-328 (Rev.), 1971.
- 17 Anderson, L. E., O. H. Fletchall, R. D. Wilson,
"1971 Recommendations for Weed Control in Corn",
Science and Technology Guide, University of Mis-
souri-Columbia Extension Division, 1971.
- 18 _____, "1971 Chemical Weed Control Recommenda-
tions for Soybeans", Science and Technology Guide,
University of Missouri-Columbia Extension Division,
1971.
- 19 Nilson, E. B., O. B. Russ, J. L. Condray, and K. C.
Feltner, "Chemical Weed Control in Field Crops,
1971", Bulletin 540, Agricultural Experiment Sta-
tion, Kansas State University, Manhattan and
Agricultural Research Service, USDA, 1971.
- 20 1971 Kansas Field Crop Insect Control Recommenda-
tions, Cooperative Extension Service, Kansas State
University, Manhattan, 1971.
- 21 1970 Activities of the Division of Entomology,
Kansas State Board of Agriculture, Topeka, Kansas,
1971.

- 22 "1971 Weed Control Manual", Farm Technology, Vol. 27, No. 3, 1971, pp. 17-99.
- 23 The Pesticide Review 1970, U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Washington, D. C., 1971.
- 24 United States Production and Sales of Pesticides and Related Products, 1970, Preliminary, United States Tariff Commission, Washington, D. C., September 1971.
- 25 Pesticide Use Reports (published quarterly), Department of Agriculture, Sacramento, California.

APPENDIX C

EFFECT OF APPLICATION TECHNIQUES

Introduction

This section attempts to show how varying pesticide application techniques and agricultural practices maximize or minimize pesticide entry into the aquatic environment.

The actual means of application are discussed, as are ways of improving application in order to minimize pesticide entry. The influence of manufacturers' recommendations on use patterns is discussed.

Many farmers feel that herbicides are essential to their successful farming, while insecticides are somewhat optional. The contractor discovered this fact while contacting farmers, and it was confirmed by the estimated use figures of pesticides in the study area. The contractor estimates a 1971 use of 84,745,000 pounds active of herbicides and 22,966,000 pounds active of insecticides. This shows the much greater dependence the farmer put on the herbicides to insure a profitable operation.

Application Techniques

The contractor estimates that 219,000,000 acres

are cultivated in the five state study area (Table 1). Of this amount, 30,487,000 acres are in corn, and 19,945,000 acres are in soybeans. Seventy percent of this area was treated with pesticides in 1971 (Tables 2, 3).

Modern pesticides are generally organic chemicals, quite powerful when undiluted, in their "technical" form. The amount of the chemical used for each acre is quite small. In order to facilitate application, and allow the chemical to be spread uniformly, it is diluted. Imagine the difficulty one would encounter in spreading 1 pound of salt uniformly over 1 acre of land. The task could be done more easily if the salt were thoroughly mixed with 1000 pounds of sand and then spread over the acre. If the mixing operation is properly done a uniform salt/sand mixture would be created and the spreader should produce an even layer. Most of the applied material would be sand, but 1 pound of salt would have been spread evenly as well. Alternatively, the salt could be dissolved in water and sprayed on the area to be treated. This is analogous to the job of applying pesticides to a field.

Most pesticides come in one or more of four forms, liquid, wettable powder, powder, and granular pellets. Liquids and wettable powders are mixed with water or

oil, then applied with a sprayer. Granular pellets are applied directly to the soil. Powdered pesticide is mixed with soil for direct application, although at the present time this is a relatively small proportion of the total amount of pesticides used.

Pesticides are applied during one of three periods, before planting, before the plant emerges, or after it has broken the ground. Application is usually made on entire field of planting. Farmers have the choice of "broadcasting" pesticide over the entire field or "banding" it along narrow rows where the crop is planted. Banding is becoming more popular as the cost of some pesticides increase. Both the banded and the broadcast materials may be left on the surface or incorporated into the top few inches of the soil. Incorporation provides a means of isolation from direct exposure to the weather and thus helps minimize potential loss and potential damage to the environment.

A group of farm journals (1) surveyed their readers to find the methods of application which farmers prefer. Seventy percent of the farmers broadcast herbicides on corn. Although the survey showed that an average of 77 percent of the farmers band their corn insecticides, in three of the five states 90 percent of the farmers follow this practice.

In three states, 60 percent of the farmers band herbicides on soybeans, while only 40 percent do so in the other two states. Insecticides are seldom used on soybeans, for there are few insect pests which prey on this plant. This picture will probably change in the future.

The contractor's survey found that in Iowa insecticides are applied as granular materials. About 85 percent of the farmers who use insecticides band them on corn, while 73 percent broadcast. Often farmers apply pesticides both ways to different fields.

Farmers are divided on the necessity of applying insecticides to corn. Published surveys (1) of farmers in the five state study area show that 42 percent use insecticides on corn, ranging from 21 percent in Minnesota to 56 percent in Illinois. Eighty-nine percent of the insecticides are usually applied in a band, with a range of 76 percent to 97 percent. These materials are usually applied at planting time, thus many are applied to the entire crop as insurance and not later as needed to control a specific pest.

The state extension service entomologists try to predict the times when a particular insect pest will invade the crops, but this is not always reliable. The exact form of application is not known, so the

pollution potential from drift of these materials is not available.

Reduction of Loss

There are several methods which a farmer can use to reduce run-off from his land and the concurrent loss of pesticides. One of the easiest ways is to apply granular pesticides and cover them as soon as they are applied since there are problems inherent in spraying. Harrold (2) has found that it can result in a 25 percent loss of dieldrin through evaporation and drift in the application process alone. By reducing run-off itself through minimum tillage, and terrace of grass in natural waterways in the field instead of cultivating the waterways, run-off carrying pesticides can be reduced. Table 1-C shows the methods that farmers use to reduce erosional losses from their lands. Local conditions will determine which method is most used and combination of methods will obviously provide the maximum benefit to the total farming operation.

About 87 percent of the farmers contacted by the contractor do try to reduce erosion by some means. However, their efforts are not coordinated nor maximized. The survey does indicate a knowledge and willingness to cooperate.

TABLE 1-C

PRACTICES UTILIZED BY FARMERS TO REDUCE
EROSIONAL LOSSES FROM AGRICULTURAL LAND

	Illinois	Iowa	Kansas	Minnesota	Missouri
Do you use any means to reduce erosion?					
No ¹	11%	16%	1%	33%	6%
Yes ²	89	84	99	67	94
Means used ³					
1. Contour plow	24	47	66	21	53
2. Minimum tillage	50	42	34	47	50
3. Other includes grass waterways, strip cropping, terraces, stubble/mulch	43	45	43	47	42

¹No response is based on total contacts for each state.

²Yes response is based on total contacts who answered yes for each state.

³Figures do not add to 100% since many made multiple entries.

Drift and evaporation are two ways applied pesticides can enter the non-target environment which can be controlled to some extent. In the chapter on Route to the Water Environment, Spencer's (3) arguments about evaporation, Harrold's (2), Frost and Ware's (4) and Caro and Taylor's (5) measurements of evaporation and drift are cited. If the moisture in the field is proper, the evaporation can be minimized. Drift is a problem locally, but as Frost and Ware (4) shows the phenomena doesn't occur very far and unless a local target exists, doesn't cause a problem.

Table 2-C shows the number of reports of drift incidents in 1970 and 1971 by the county agents.

Banding of pesticides, reduces pesticide run-off by reducing the area to which the material is applied, but is difficult to do once the crop has emerged. Research into ways of efficiently combining banding with cultivating could solve this problem.

Application Equipment

Applying the correct amount of pesticide is important. Any amount greater than the minimum required only acts to damage the environment. To this end, we asked farmers how their application equipment works in terms of calibration of rates. The results are in Table 3-C.

TABLE 2-C

INCIDENCE OF PESTICIDE DRIFT AS REPORTED BY COUNTY AGENTS

Approximate Incidences	Illinois	Iowa	Kansas	Minnesota	Missouri
1970	232 to 239+	221 to 241+	318 to 319+	141 to 152+	36 to 36+
1971	401 to 414+	256 to 278+	240 to 241+	124 to 136+	56 to 56+
Estimate of trend	incr.	incr.	decr.	decr.	incr.

TABLE 3-C
PROBLEMS ENCOUNTERED WITH CALIBRATION¹ OF
EQUIPMENT USED TO APPLY PESTICIDES¹

Extent of Problem	Illinois	Iowa	Kansas	Minnesota	Missouri
1. None	45%	29%	35%	41%	47%
2. Few	22	39	43	28	31
3. Some	27	20	13	26	11
4. Many	6	2	--	--	4

¹Based on 288 farmers who apply or use pesticides out of 331 contacts.

The contractor believes inspection of the problems encountered with calibration of equipment is warranted. Agents and retailers indicated that this problem comes up every crop season. The farmers themselves feel they have few problems with calibration. However the number of farmers responding "few" or "some" to this question suggests that there is a continual minor problem with equipment. Many of the farmers contacted had ingeniously modified their equipment to implement application. It would appear that manufacturers and agricultural engineers could contribute by attempting to fit more uniform granular formulations to better engineered application equipment.

The Applicators

Pesticide contamination of the environment can be minimized by better application techniques and by a better understanding of the problems and dangers of pesticides. The farmer may apply pesticides himself or he may hire a commercial applicator to do the job for him. Both groups could benefit from instruction.

A high percentage of farmers apply their own herbicides (Table 4-C). A smaller percentage apply their own insecticides. Application by commercial or professional firms is an alternative. We asked county

TABLE 4-C
PROPORTION OF FARMERS WHO APPLY
THEIR OWN PESTICIDES

	Illinois	Iowa	Kansas	Minnesota	Missouri
1. Apply Insecticides					
Yes	61%	70%	49%	39%	58%
No	39	30	51	61	42
2. Apply Herbicides					
Yes	90	78	67	89	70
No	10	22	33	11	30

agents for their opinion of custom applicators. Table 5-C shows the response.

Agents contacted by the contractor gave some interesting responses on the subject of commercial application of pesticides. There appears to be a wide variation in the agents understanding and knowledge of the people who apply these products on farms. If their estimates are correct, a variation of 10 percent to 80 percent commercial application exists between counties of any given state. The agents report (Table 5-C) that slightly more insecticides than herbicides are commercially applied. This is uniform over the region and probably reflects the farmers knowledge of the hazards in handling these compounds.

Agents from Illinois and Minnesota are aware of the prevailing state law licensing applicators and said so. Agents from Kansas apparently aren't sure whether or not licensing is required. At least two agents from Iowa think that a license is not required, (it is) and one from Missouri thinks it is (it is not). See Appendix G.

Whether or not the commercial applicator has been adequately trained or is qualified requires a subjective judgment. As one agent commented ". . . I know he (the applicator) has had training. . . but he doesn't act

TABLE 5-C

COUNTY AGRICULTURAL AGENTS ASSESSMENT OF COMMERCIAL
APPLICATOR ABILITY AND TRAINING

	Illinois	Iowa	Kansas	Minnesota	Missouri
1. Approximate percent- age of farmers who hire someone to apply:					
Insecticides	40%	30%	70%	60%	50%
Herbicides	25%	30%	50%	50%	30%
2. Have they had train- ing?					
Yes	41	25	30	38	13
No	4	5	9	5	9
3. Is license required?					
Yes	45	41	21	45	1
No	--	2	15	--	18
4. Are they qualified in your opinion?					
Yes	37	32	25	36	10
No	5	13	14	9	11

like it." The agents believe that most of the applicators have had some training.

Qualifications of the applicator were viewed as at least adequate by agents from Illinois and Minnesota, as might be expected for they have good laws. Many felt that a much larger number are not qualified in Kansas, Missouri, and Iowa.

The agents were unanimous in feeling that applicators should attain a certain level of knowledge before being allowed to apply pesticides.

Comments from some of the agents are included on the following pages. No attempt was made by the contractor to evaluate these comments.

Recommended Treatment

Most county agents from Illinois, Iowa, Minnesota and Missouri feel that farmers do use the recommended amounts of pesticides. Cost is the deciding factor. Relatively more agents from Kansas feel recommendations may not be followed (Table 6-C). Pesticide residues may remain on a field over a year, but few farmers take this fact into consideration when calculating the amount of pesticide to apply. The agents from Illinois, Iowa, Kansas, and Missouri point out that no one has given the farmer a method to make this evaluation. The

MISSOURI

- Definitely, especially with parathion.
- Some are trained by dealers, but not well enough.
- Most just add lines of products and learn application by trial and error.
- Yes, should have to pass a test.
- Not sure about how this should be done.
- We have formulators who will mix anything! If results are poor, applicator is blamed. I answer all negative. Some are trained and are qualified, others are not. We need laws that require training and periodic certification and laws with sharp teeth.
- Most commercial applicators are well qualified - have only a very few of them. Yes, a certain level of knowledge about pesticide dangers and methods of safe application should be required.
- Aerial applicators, especially should be trained in the use of all chemicals that they may be applying. Each year considerable 2,4-D damage is done to certain crops by careless aerial applicators.
- Most of our commercial applicators are well trained. I feel they should be required to take test and achieve a certain level of knowledge.
- A practical training program and examination should be considered.
- The commercial applicators know what they are doing.
- I would like to see a license for the application of pesticides.
- Many are experienced in the use of certain chemicals, doing a good job. Some regulation is necessary but precautions should be taken to guard users cost. We can legislate starvation.
- Herbicides and insecticides are broadcast. Most of the work is done by the farmer in the normal years. However, in wet years, field work may lag and the farmers may take more advantage of aerial application.

ILLINOIS

- Yes, but they often have personnel that are not qualified for custom work.
- Most custom operators are good. There are a few who do not follow label instructions.
- The state requires custom applicators to pass exams.
- Operator should be current on information available.
- The law is quite difficult to police.
- To obtain a license, one must demonstrate a certain level of knowledge.
- Too much damage from airplane spraying.
- Some operators are qualified, some are not. License is issued to firm, not individual.
- Although they may be licensed in 1971, will they keep up with all changes in 72?
- Depends upon training given person who actually does the work.
- Some could use more practical instruction or ways of precautions.
- Knowledge of the pesticide and rates, effectiveness, etc.
- Supervisors are knowledgeable, but some hired personnel of commercial applicators are not adequately trained.
- Yes, particularly as to proper chemical use, safe use of chemicals, and calibration procedures.
- Licensing is increasingly important.
- Each year some errors are made in amounts and location, but this is a minimum. An applicator soon learns the technique of application if he doesn't already know at the beginning of the season.

IOWA

- The person doing the application should have the license.
- Both Manager and employees should be required to pass very difficult tests.
- There needs to be a strong deal training program each year.
- Iowa should have better means of registration, licensing, regulation.
- Level of knowledge should be required. (3 agents made this reply).
- Should have proper knowledge pertaining to chemicals used.
- Practical experience is important, some required knowledge is required for license.
- A lot of commercial applicers pass the test and still aren't as well informed as they might be. However, no knowledge is required for anyone putting on their own pesticide.
- A big difference in knowledge of applicators, most are qualified, some are questionable.
- A test could be the screening tool.
- The manager has to pass a state test, the applicator himself may not be adequately trained.
- They are sometimes caught between making a sale and recommending what they know is best.
- They should know their equipment, and keep it in top operating condition.
- Permits are used instead of license, manager, only, operator not required, is trained by manager.
- Yes, in area of plants so treated for food and safety as regards harm to people.
- The license makes them keep up to date.

KANSAS

- Several schools are offering courses in pesticide usage which every commercial applicator should be required to take.
- All commercial applicators should have training in the use of pesticides.
- In some cases training should be required.
- A person should know how to read and follow directions.
- Some applicators tend to use poor judgment, applying 2,4-D with 70 mph wind velocity.
- Attitude towards proper use is important. Competition and poor attitude help them bend the rules. Most dealers, though, are reasonably ethical.
- Yes, especailly in determining selection of mixture of chemicals.
- Applicators don't have enough knowledge to be using these chemicals.
- Commercial applicators should be licensed and bonded, farmers should be exempt.
- Should have education and pass a definite exam.
- Should receive university extension or N.S.D.A. instructions, with required attendance for 1 to 2 days.
- Kansas is ahead of many other states.
- Most are qualified in rural areas. Urban operators are not really qualified.
- Should know safety precautions, the amounts to mix, damage that can be done.
- State legislation passed will require licensing of applicators.
- In most cases applicators are adequate.

MINNESOTA

- Some are well trained and well qualified, others are not.
- Would be helpful - very few people in our county are interested in being licensed.
- Not all are well qualified/well trained, but all think they are experts in application, chemicals, and related information.
- Commercial applicators must have good working knowledge, perhaps farmers too should be required to show they have knowledge to handle materials safely.
- Minnesota State Department of Agriculture requires test to be passed before issuance of license. Sprayer equipment must also be licensed if used commercially.
- Knowledge should be required. Some are competent, other not - hired help by retailers often not competent.
- Absolutely, they should be knowledgeable as to all aspects of health, safety, and environmental effects.
- Those with experience and willingness to obtain information are well qualified.
- Yes, I believe a certain level is required to lessen error which in turn cause problems in our public relations.
- Yes, definitely. In Minnesota applicators need to take a test.
- The owner of the license is, some operators are not.
- Yes, should have a good understanding.
- Examination by state agricultural department is adequate.
- Actual operator does not need a license - only owner of contractor of equipment.
- Yes, it all helps, and they are learning more each year.

TABLE 6-C

AGRICULTURAL AGENTS ASSESSMENT OF RECOMMENDED AMOUNT
OF PESTICIDE USED AND RESIDUE CALCULATIONS

	Illinois	Iowa	Kansas	Minnesota	Missouri
1. Feel that farmer uses recommended amount of pesticide					
Yes	43	41	29	38	28
No	7	3	13	8	8
2. Take residue into consideration when calculating amount to use in current crop year					
Yes	16	16	14	22	9
No	32	30	26	20	11

farmer is not at fault here; he simply lacks one of the tools to make his operation more economical.

Professional agriculturalists have estimated that much of the soil in Illinois is carrying dieldrin residues of up to 25 percent of that applied (as aldrin) from year to year. Taking this into consideration could amount to a substantial saving.

Many of the farmers from Minnesota appear to take residues into account. The organic matter content of the soil is higher and tends to predispose higher residue levels. The farmers are made more aware of it.

It is sufficient to add that any consideration of existing residue levels and the addition of these levels to any current crop years pesticide use anticipated could amount to a considerable savings to the environment and especially the aquatic ecosystem.

Summary and Conclusions

Pesticides are available to farmers as liquids, wettable powder to mix with water, granular pellets, and powder to be mixed into fertilizers. These materials are either broadcast over an entire field or applied in rows or bands parallel to and centered on the rows of crop. Banding is a means of reducing the amount of pesticide needed. Typically only 7 inches out of 30 inches are treated.

An educational effort is called for, supported by proper unbiased research into usable techniques for identifying pest trouble areas, informing farmers of potential trouble and how to implement effective counter-measures. Remote sensing techniques may be useful. With such a plan a scheme of total crop and pest management can result in efficient operations and reduced chemical cost.

A massive education program is also needed to inform pesticide users, applicators and those who may come into contact of the dangers and hazards of pesticides and to insure safe container disposal. Intensive campaigns may be needed to convince the farmer to properly dispose of his empty bags, cans, and other containers and to protect himself while working with the chemicals. Also needed is a systematic collection and disposal system for used pesticide containers. Instructions need to take into consideration field conditions and the potential difference in education between writer and user. All directions should be field tested just as new products for the home kitchen are test marketed. The development of a pest management system concept of pesticide use for crop protection without significant yield loss is discussed in the following recommendations section.

Recommendations

The contractor would like to recommend a massive research effort to establish safe, effective, economical, practical solutions to the problem of empty pesticide container disposal. In the interim labels should be easily understandable so that directions can be followed under actual field conditions.

To help minimize contact with the toxic chemicals, plastic disposal gloves and a respirator mask, if needed, should be attached to the outside of every pesticide container holding chemicals for farm use. The user would be inclined to use safety equipment if it were there when he picked up the package.

Studies of effective agricultural techniques for reducing environmental damage such as minimum tillage, grass waterways, and banding of chemicals should be made and results publicized along with an effective implementation plan.

Mechanisms of pesticide entry into the aquatic environment, the potential harm of the practices such as fall plowing should be publicized and alternative countermeasures developed.

There are now few insect pests which bother soybeans. The probability is that they will increase. The contractor feels that this would be a good area to

institute a total management scheme.

The manufacturers of pesticides have a well established system for promoting their products to the farmers. The contractor queried pesticide retailers throughout the study area to see if availability of compounds is a problem. The answer most frequently given was "seldom", somewhat fewer saying "occasionally." The manufacturers have set up a distribution to get the materials to the farmer when he wants them. They also advertise heavily in the farm journals, often with full color, double page spreads. The farmer is encouraged to use more, not less, material. The contractor's survey of county agricultural agents found that agents feel the farmers do not take pesticide residue into account when calculating the required amount of material for the current year. In Minnesota, where higher organic content soils tend to hold more pesticide, the agents were evenly split about consideration of soil pesticide residue. Economic feasibility was considered to be the major limiting factor.

In the corn producing area, the use of insecticides is well established. Pesticides tend to be used as insurance of a good crop, rather than as a specific remedy to a problem when it arises. The pressure the manufacturers place on farmers, on retailers, and to

some extent through county agents prevents a change in use patterns from developing.

The contractor feels very strongly that a pest management program should be used, for both herbicides and insecticides to combine all agricultural practices, including selected use of pesticides on diagnosed problems such as corn rootworm in one field when it occurs, rather than a blanket application of aldrin to an entire crop at planting time. Soybeans would be a good place to develop such a scheme. Insecticides are not used on soybeans, but might be needed if conditions change. The approach needed is active education of farmers to this idea, and rapid, usable advice from the state agricultural departments. This might be done through use of county agents, radio, television and newspapers to describe each problem and recommended solutions.

A systems approach to the pest problem could bring about a major reduction in pesticide usage without significant loss in crop yield or expense to the farmer.

LITERATURE REFERENCES

- 1 Agricultural Chemicals Survey Report, Iowa, 1970, Research Department, Wallaces Farmer, Des Moines, Iowa; Agricultural Chemicals Survey Report, Indiana and Illinois, 1970, Research Department, Prairie Farmer, Des Moines, Iowa; Agricultural Chemical Survey Report, Minnesota, South Dakota, and North Dakota, 1970, The Farmer, St. Paul, Minnesota; Agricultural Chemicals Survey Report, Missouri, 1970, Missouri Ruralist, Cleveland, Ohio; and Agricultural Chemicals Survey Report, Kansas, 1970, Kansas Farmer, Cleveland, Ohio.
- 2 Harrold, L. L., Research on Agricultural Pollution in Ohio, 1971.
- 3 Spencer, W. F., "Distribution of Pesticides Between Soil, Water, and Air", Pesticides in the Soil, Michigan State University, 1970.
- 4 Frost, K. R., and G. W. Ware, "Pesticide Drift from Aerial and Ground Applications", Agricultural Engineering, 51, 460 (1970).
- 5 Caro, J. H., and A. W. Taylor, "Pathways of Loss of Dieldrin from Soils Under Field Conditions", Agricultural and Food Chemistry, 19, 379 (1971).

APPENDIX D

ROUTE OF PESTICIDES INTO WATER ENVIRONMENT

Introduction

This chapter details how pesticides enter the water system from a point of application or from some other point source. Since many insecticides and some herbicides are insoluble in water they are not dissolved at the site of contamination; instead they are physically transported to permanent bodies of water by one of several mechanisms. The most important of these mechanisms is adsorption into soil particles which are later carried into water during run-off. Evaporation, drift of spray and residue from empty containers also may be important factors. The problem of container disposal is developed and the chapter is highlighted by a study of pesticides in one of the states, Iowa. The effectiveness and limitations of monitoring data systems also are discussed.

Soil Types

Soil is "a function of various environmental factors rather than a product of the interaction of these factors." (1)

Five factors operate in this function: (1) parent material whose characteristics, texture, structure, and chemical and mineral composition, affect the soils it forms; (2) soil biota, vegetative cover and organisms within the soil; (3) climate, including variations in temperature and amount and kind of precipitation; (4) topography, especially as it affects internal and external drainage and variations in climate; and (5) time period in which pedologic processes have been operating. These factors all interact with one another; soil cannot be viewed as an end product of an operation but rather as a dynamic process. Each factor is inter-related to and interdependent. Variation in one factor affects the others.

In the five state region there are seven types of soils as shown in Figure 1-D, Alfisols, Entisols, Histosols, Inciptisols, Mollisols, Spodosols and Utisols.

Mollisols are predominant in the study area. The surface layer is dark, with more than one percent organic matter, and at least ten inches in thickness. This layer and the B horizon have a base saturation of more than 50 percent, with calcium the predominant base. There is wide variation in characteristics which affect erodability (such as texture and permeability).

The surface layer of Alfisols, the second most

LEGEND:

-  Alfisols
-  Entisols
-  Histosols
-  Inceptisols
-  Mollisols
-  Spodosols
-  Utisols

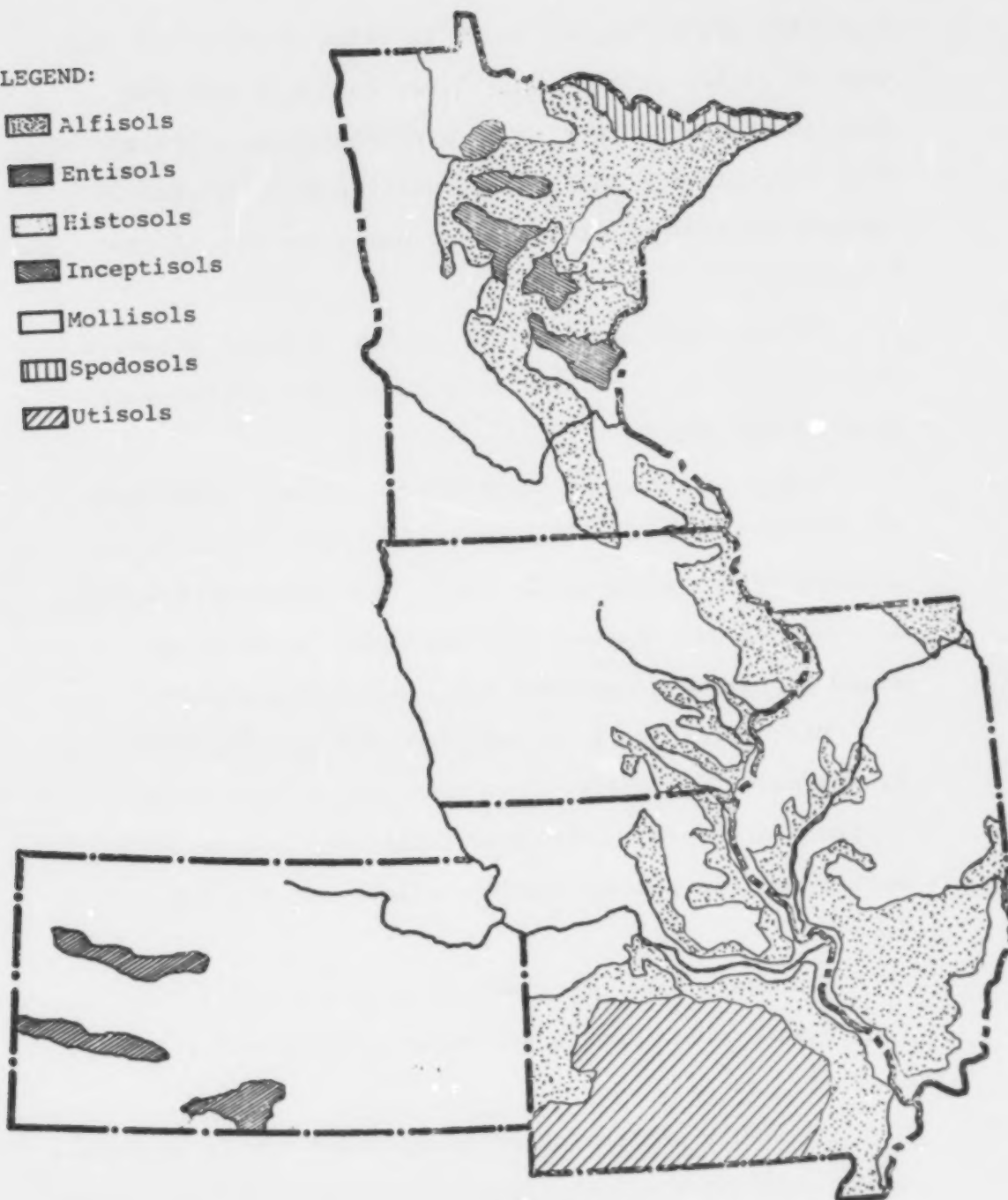


FIGURE 1-D
MAJOR SOILS IN FIVE STATE STUDY AREA

important group, may be light in color or dark and less than 10 inches thick. This layer has less than one percent organic matter, with a recognizable B horizon of clay accumulation and base saturation of more than 35 percent at a depth of 50 inches below the top of the B horizon.

Udisols are found mainly in the state of Missouri. They are low in bases and have subsurface horizons of clay accumulation.

Entisols are more important in Kansas. They lack distinctive horizons, and thus are either recently deposited soils, sandy soils which lack sufficient materials which could weather into horizons, or soils on steep slopes where erosion has limited development.

Most Inceptisols in the study are found in Minnesota. They differ from Entisols in that their horizons are weakly developed. They may not necessarily be older, since their horizons can develop rapidly.

Histosols also occur mainly in Minnesota. They are organic soils, peats and mucks. Unless artificially drained, they are wet.

Spodosols are the third group found mostly in Minnesota. They have a subsurface horizon of an accumulation of organic matter in addition to compounds of iron and aluminum.

Transport Routes

Several pesticide transport routes are known or theorized to contribute to the presence of pesticides in water. These routes are summarized and ranked in Table 1-D.

TABLE 1-D

IMPORTANT PESTICIDE TRANSPORT ROUTES
(descending order of importance)

<u>Route</u>	<u>Importance</u>
1. Adsorption + movement on sediment	Greatest
2. Application loss spray operations	Great
3. Drift	Potentially Great
4. Empty Container Disposal	Potentially Great
5. Evaporation from land	Moderate
6. Solubility in water	Low - Med for some herbicides
7. Accidental Spills	Low - Potentially
8. Deliberate	Very Great

Many pesticides used by farmers are extremely insoluble in water; however some pesticides, including herbicide derivatives have appreciable solubility and direct solution may be a significant transport route.

Table 2-D shows the water solubility for three important materials in the study area.

TABLE 2-D

WATER SOLUBILITY OF SELECTED PESTICIDES (2) (3) (4)

<u>Compound</u>	<u>Solubility</u>
Aldrin	11 ppb
Dieldrin	110 ppb
Atrazine	33 ppm

Soil Transport

The low solubilities indicated above ensure pesticides cannot travel as a water solution, but must be carried in suspension. This suspension may be chemical, as in the emulsion used to apply the material, or, more commonly, adsorbed on soil particles carried by water in the normal process of erosion.

Erosion is a geologic process occurring on all land masses at all times. The force of gravity which causes erosion is continually acts to level the earth's land masses. Of the three erosion agents - water, wind, and glaciers - water is currently the most important in the study area.

The level of sediment a given amount of water can carry is determined by the total amount of water and by the water's route. Rainfall routes to a stream may be divided into two categories, run-off and soil absorption.

This study is concerned primarily with run-off.

The rate of precipitation and the moisture content of the soil determine how much water will be absorbed. The rest will run off. The energy of run-off - the factor which determines the amount of sediment the water can transport - is determined by slope gradient. The steeper the hill, the greater the energy. Swith and Wechmeier have developed a formula for predicting erosion (5). Sediment transport is the most important method of introducing pesticides into the water environment. Depending on flow conditions, this sediment may be carried to a river or deposited on the bottom of a waterway.

Sediments are measured infrequently due to the tedious methodologies required to accurately determine the range of materials present. Table 3-D shows several locations where these measurements were made within the study area.

The St. Louis figure indicates a loss of about 600 pounds/acre annually for the entire Mississippi watershed above St. Louis. Since about 36 percent of the land is cultivated, the loss is approximately 1700 pounds/acre.

A farmers' survey completed by the contractor showed that few respondents (21 percent in the five-state region) could estimate soil loss from their farms. The average

TABLE 3-D
SELECTED SEDIMENT MEASUREMENTS
IN FIVE-STATE STUDY AREA

Place	River	Amount of Sedi- ment (tons/year) (6)
Mankato, Minnesota	Minnesota	820,211
St. Louis, Missouri	Mississippi	118,358,500
Red Oak, Iowa	E. Nishnabotna	1,576,799
Chariton, Iowa	Chariton River	56,209
Winfield, Kansas	Walnut River	1,015,712
Arkansas	Arkansas River	1,598,572
Wanego, Kansas	Kansas River	1,104,402

loss reported was 0.56 inch/acre. This estimate of the unknown is too high when considered with the time needed to produce new soil, and is not corroborated by the sediment loss estimate derived from Table 3-D.

Another unknown is the level of pesticides expected in the soil. Taylor (7) has reported the difficulty of measuring pesticide residues in soils due to extreme variability over even small areas. He found fold variation in measured pesticide concentrations of a 36 square meter plot. Table 4-D shows average values from Aldrin, dieldrin and atrazine found in three of the study states by the United States Department of Agriculture (8). Distribution of these values is shown in Figures 2-D through 7-D.

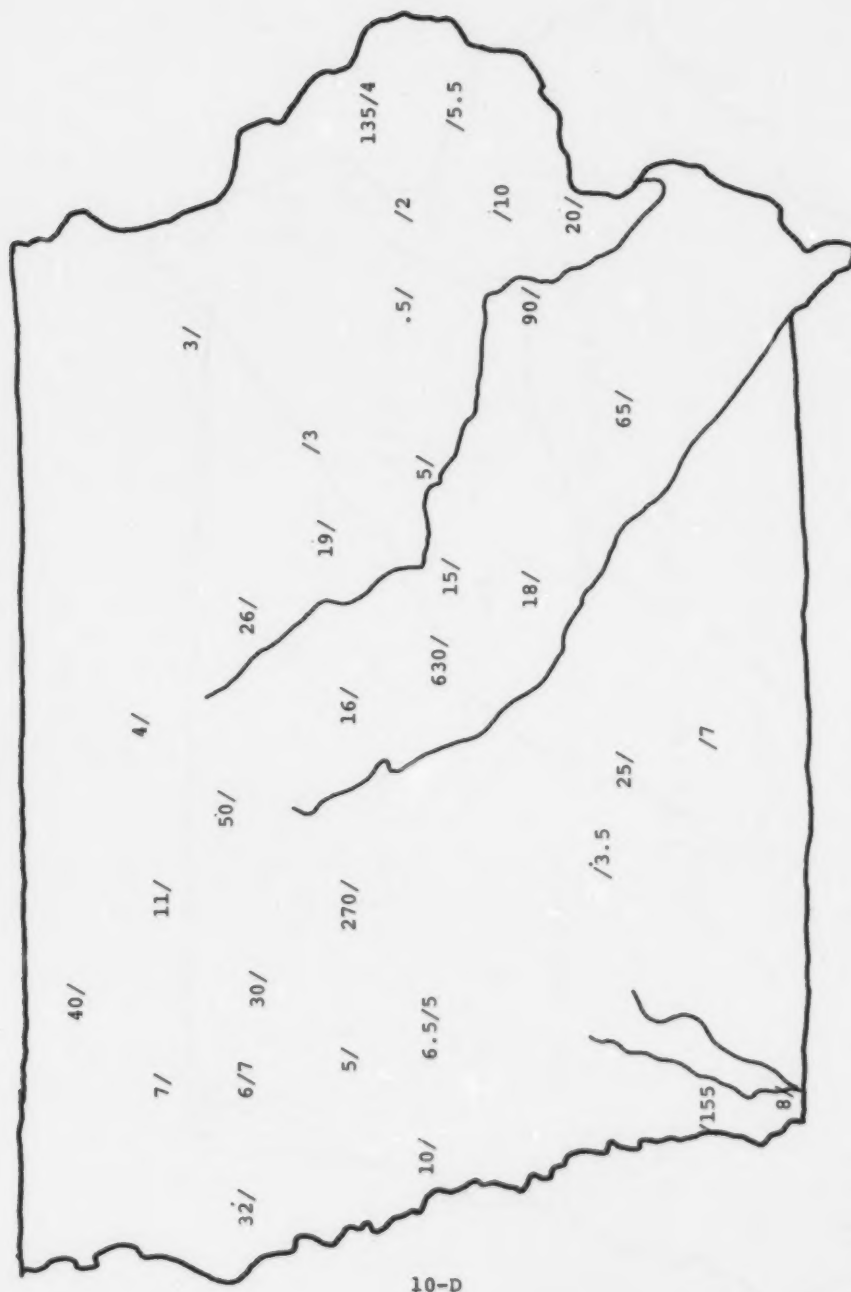


FIGURE 3-D
CONCENTRATIONS OF CHLORDANE/ATRAZINE FOUND
IN IOWA SOILS (in parts per million)

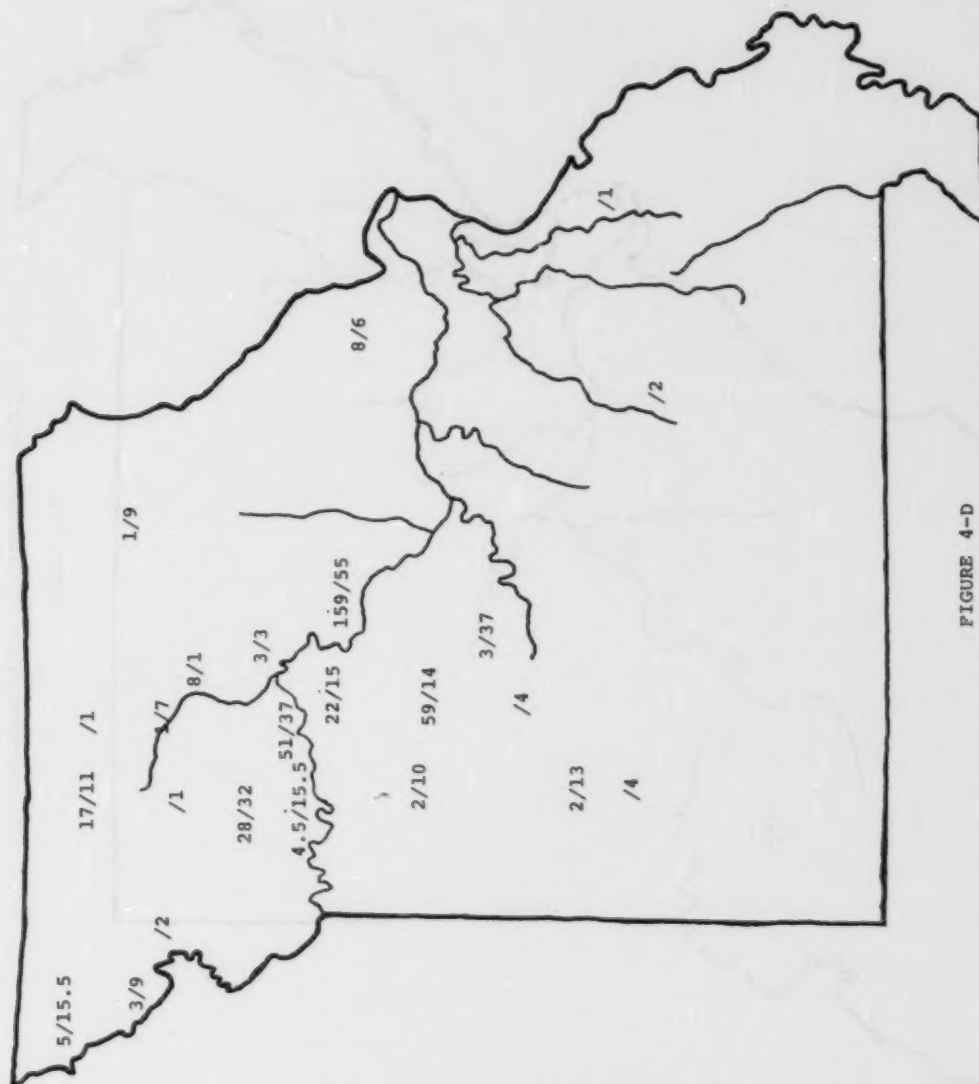


FIGURE 4-D
CONCENTRATIONS OF ALDRIN/DIELDRIN FOUND
IN MISSOURI SOILS (in parts per million)



FIGURE 5-D
CONCENTRATIONS OF CHLORDANE/ATRAZINE FOUND
IN MISSOURI SOILS (in parts per million)

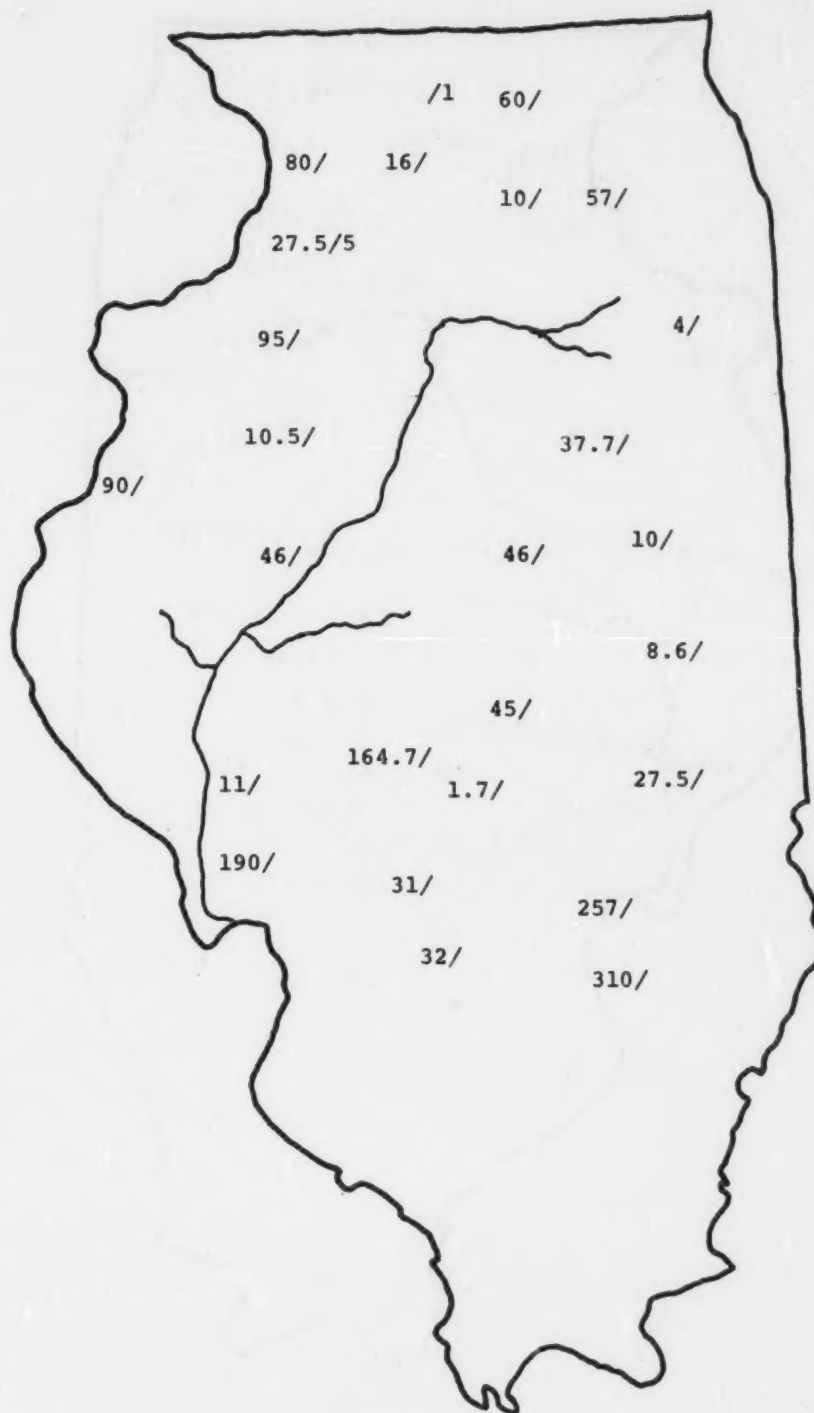


FIGURE 6-D

CONCENTRATIONS OF CHLORDANE/ATRAZINE FOUND
IN ILLINOIS SOILS (in parts per million)



FIGURE 7-D

CONCENTRATIONS OF ALDRIN/DIELDRIN FOUND
IN ILLINOIS SOILS (in parts per million)
14-D

TABLE 4-D
AVERAGE SOIL PESTICIDE VALUES

State	Compound	Value (ppm)
Illinois	Aldrin	0.147
	Dieldrin	0.138
Missouri	Aldrin	0.133
	Dieldrin	0.129
Iowa	Aldrin	0.07
	Dieldrin	0.107
	Atrazine	0.05

When these figures are related to measured sediment carried in the Mississippi at St. Louis, resulting calculations show that about 14 tons of dieldrin are annually carried in the Mississippi at St. Louis. However, measured sediment values for dieldrin in Iowa (9) range from 1.7 to 35 ppb, with an average of 11.1 ppb. If this amount of dieldrin was in sediment at St. Louis, the total carried annually would be only 260 pounds as compared to 14 tons calculated above.

Better measurements are needed before more accurate conclusions can be drawn about the quantity of pesticides in the water environment. There are no

obvious effects to man from this level of material as shown in the impact chapter of this report. It has been shown (9) that factory workers producing these materials are exposed to greater levels of these compounds without harmful effects (10).

Certain features of a soil make it prone to erosion. Martin, et al. (11) report that high organic matter and finer particles of soil tend to be eroded first and fastest. The less dense organic material is in higher concentrations at the surface and tends to be subject to heavier erosion. Organic matter in the soil traps pesticides tightly; thus erosion mechanisms and pesticide chemistry combine for a greater potential impact on the environment. Measurements were taken of 950 pounds per acre of organics lost in one year, and 668 pounds after erosion had progressed.

Some Minnesota soils have a 3 percent or more organic content. This soil holds greater amounts of pesticides thus reducing the amount required for application after the first year.

Many factors may influence the soil's capacity for pesticides including organic content, pH, colloidal clay, cation exchange capacity, and moisture retention. Usually organic carbon correlated better with pesticide levels than any other parameter. However in some soils with

some pesticides the parameters may be insensitive to the capacity (12).

Total erosion has been estimated at 4 billion tons, or 4 million acres 6 inches deep of good topsoil (13). Oschwald (14) reports a total camage of \$25 million a year due to sediment in the Upper Mississippi alone, with almost \$6 million lost in reservoir capacity and river dredging operations. Thus erosional soil loss is a major problem without consideration of the soil as a pesticide carrier. The Soil Conservation Service of the Department of Agriculture has created the "universal Soil Loss Equation" to help a farmer estimate and control this loss. About 35 parameters are evaluated and fed into an equation to predict soil loss in tons per acre per year. However, the equation cannot be used to estimate sediment entering a watershed since it was developed as a measurement of land loss, not watershed gain. The contractor did not contact any farmer mentioning application of this equation to his land.

Quantity of Pesticides in the Environment

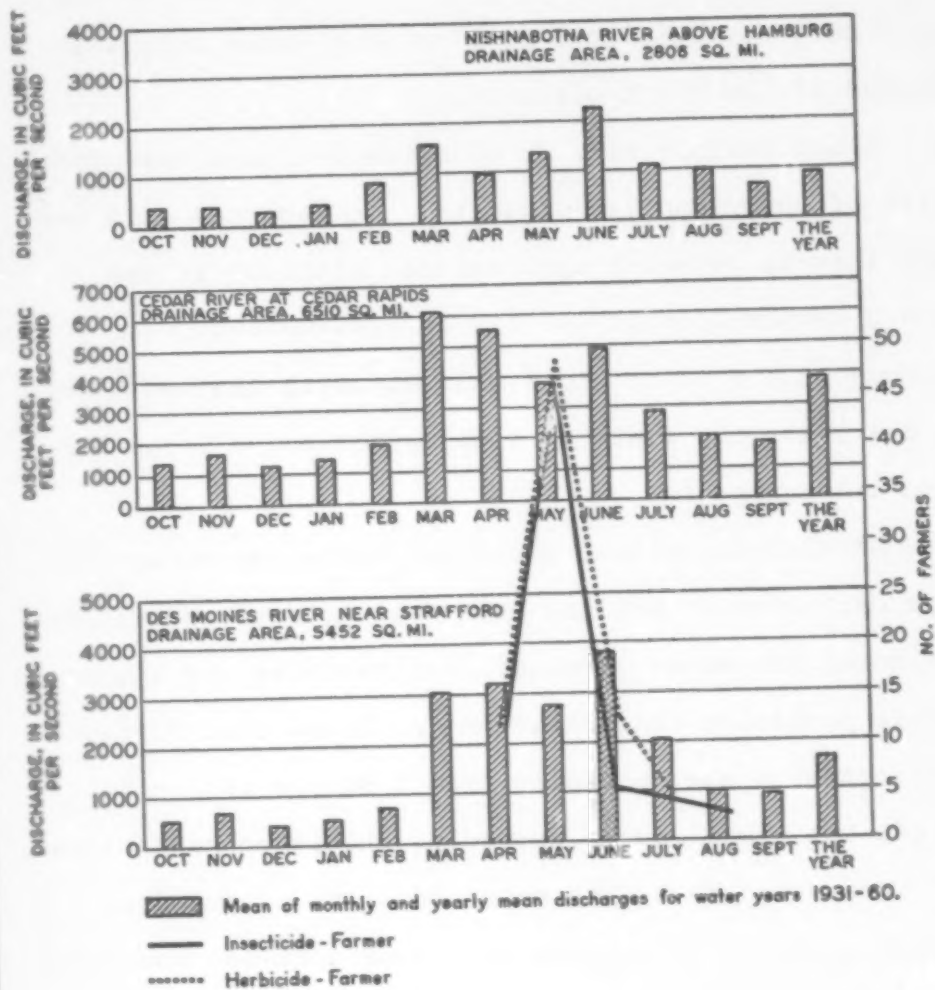
A fraction of the pesticide applied to an agricultural field under specific circumstances may be moved into the water environment. The pesticide travels predominantly with sediments in which it is adsorbed (15) (16) (17). Direct contamination of water by free pesti-

cide is seldom a problem since as a group, pesticides are essentially water insoluble organic compounds. Transport of pesticides is further detailed in the "Soil Transport" section of this report.

Other Transport Routes

The contractor's surveys found that farmers apply the largest portion of their yearly pesticide dose when run-off is most likely to occur. Figure 8-D shows a clear peak in May, as indicating the time of year pesticides are applied. The retailers surveyed show a slight tail on the sales for post-emergence use, but this is relatively insignificant in the total use pattern. However, the 30-year discharge patterns for three rivers in Iowa, which the United States Geological Survey (6) terms representative of river flows in that state, show peaks (bars on graph, Figure 8-D for May of each year), the same month farmers apply pesticides. Since high discharge means large run-off from the fields with corresponding high sediment transfer rates, from an environmental standpoint, pesticide application comes at the worst possible time of the year. This same phenomena is true in each of the other study states.

Minor transport routes to the water include wind-carried drift from application directly to the water,



19-D

TIME OF APPLICATION
OF PESTICIDES

and evaporation of active material and subsequent precipitation with rain. Generally, drift is a minor problem because of the short distances involved. However this could be a serious local problem if a water body was located within drift distance.

Lloyd Harrold (15) in Ohio has measured loss from drift of spray-applied dieldrin. He reported a 25 percent loss in material application, although it was into 3 inches of soil the day of application.

Although there is no proof this material reached water, it did leave the field of application and a large portion did evaporate.

After evaporation, pesticide vapor may attach to dust particles or collide with falling water particles and enter the water. Pooler (18) has measured atmospheric pesticide concentration and found that "direct continental scale spreading from a source can be fairly rapid, but global scale spreading should be much slower."

Frost and Ware (19) measured drift produced in aerial spraying as opposed to ground spraying and found that the former produced four to five times as much drift as the latter. On the ground one large nozzle produced less drift than three smaller units while covering the same area.

Thus, spraying from the ground using equipment with

a few large nozzles rather than several small ones produces less drift.

Lloyd (15), Caro and Taylor (16) of Ohio also measured evaporation of dieldrin from farm land and found that 2 percent of the dieldrin evaporated during the year of application. Spencer (18) confirmed these findings for dieldrin and lindane, and theorized the evaporation in terms of competition between water in the soil and pesticides for available adsorption sites within the soil. When the soil is very dry, pesticides adhere to soil particles and remain in one place. But when the soil becomes slightly wet, water displaces lindane or dieldrin, and pesticide vapor pressure and volatility increase with resulting loss from soil into the atmosphere. This theory could be significant in terms of the total loss of pesticides from soil.

Table 1-D (see "Transport Routes," this chapter) shows that atrazine has a solubility of 33 ppm, which is significantly greater than that of chlorinated hydrocarbon insecticides. The result is that some atrazine may be leached from the soil by water and carried as a water solution. Ritter (20) at Iowa found that:

Generally pesticide concentration [was] higher in sediment than water but greater losses [were] associated with the water phase than the sediment because of the greater volume of water.

A storm producing 1.15 inches of rain one week after an atrazine application resulted in a 15 percent loss of applied material on contour plowed land, and 2.2 percent loss on ridge plowed land. As suggested by Ritter, ridge plowing of corn could reduce pesticide loss considerably. Atrazine is not extremely toxic to fish and its effect on the aquatic environment is minimal.

After insecticides are applied to the soil, they must last long enough to be transported to the water to cause a problem. If rapid break down of compounds occurs and the broken down compounds are not toxic there is no problem to the environment.

Figures 9-D, 10-D, 11-D, 12-D (21) shows the persistence of several selected pesticides. At least one of these, telodrin, is no longer manufactured because of its high degree of toxicity. However it also degrades quickly and completely, not merely reverting to another more persistent form as do aldrin/dieldrin and heptachlor/heptachlor epoxide.

Within eight weeks some compounds degrade completely while others do not deteriorate at all. Based on the persistence factor, the most desirable choice of pesticide from an environmental viewpoint is the material which degrades rapidly and is non-toxic.

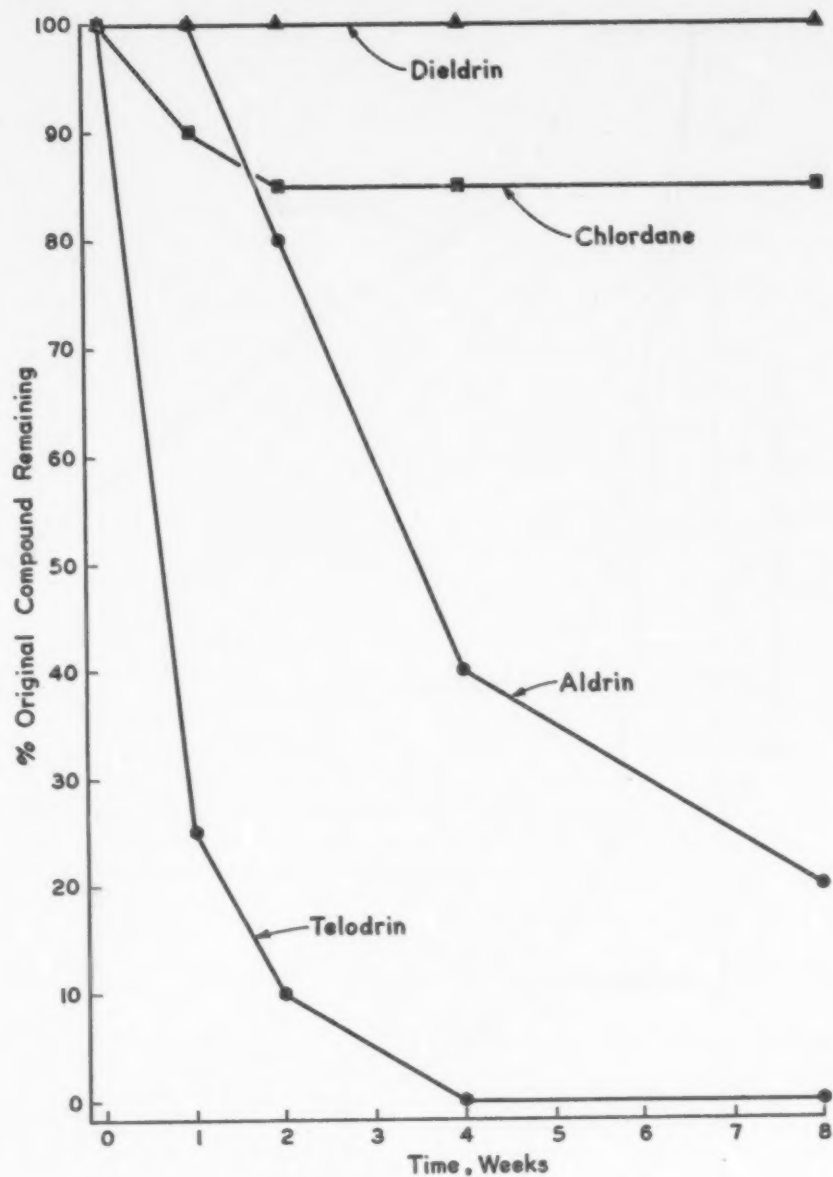


FIGURE 9-D

MEASURED PERSISTENCE
OF PESTICIDES IN
RIVER WATER
ORGANOCHLORINE
COMPOUNDS

RETA
1025

23-D

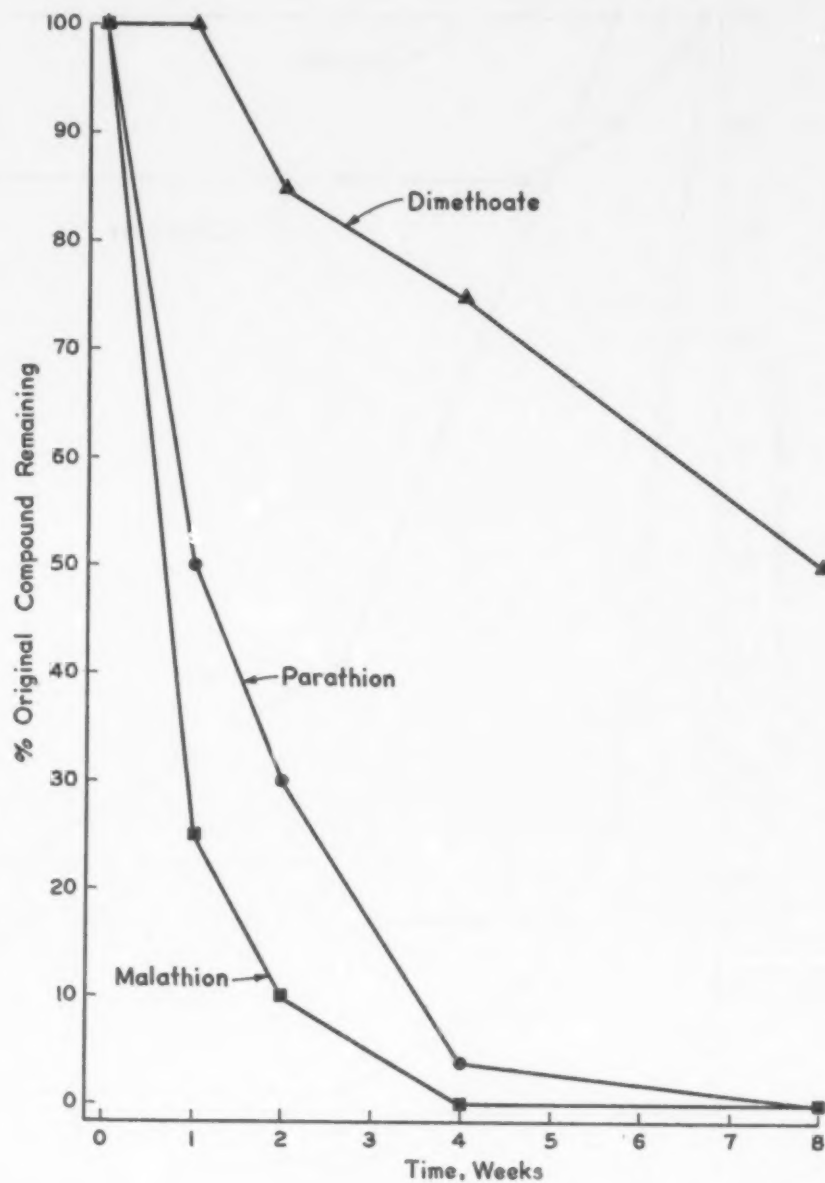


FIGURE 10-D

MEASURED PERSISTENCE
OF PESTICIDES IN
RIVER WATER
ORGANOPHOSPHORUS
COMPOUNDS

RETA
1025

24-D

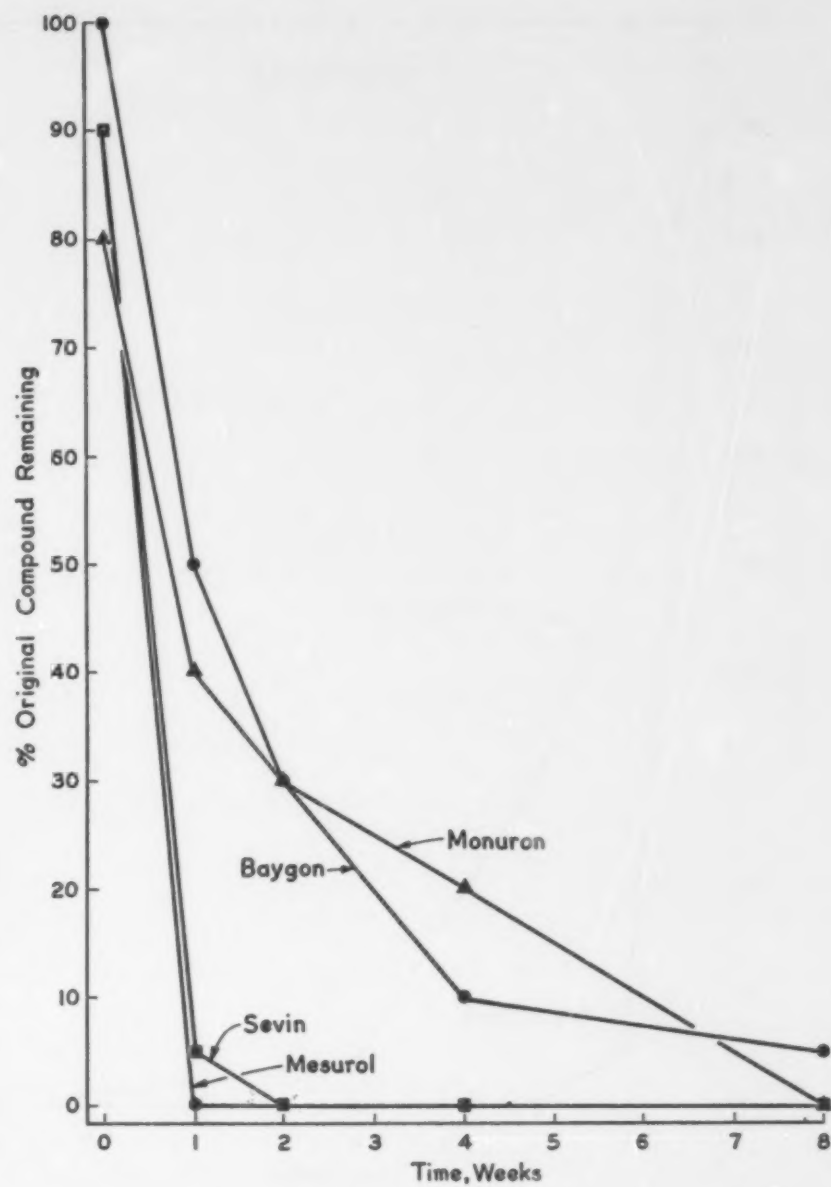


FIGURE 11-D



25-D

MEASURED PERSISTENCE
OF PESTICIDES IN
RIVER WATER
CARBAMATE COMPOUNDS

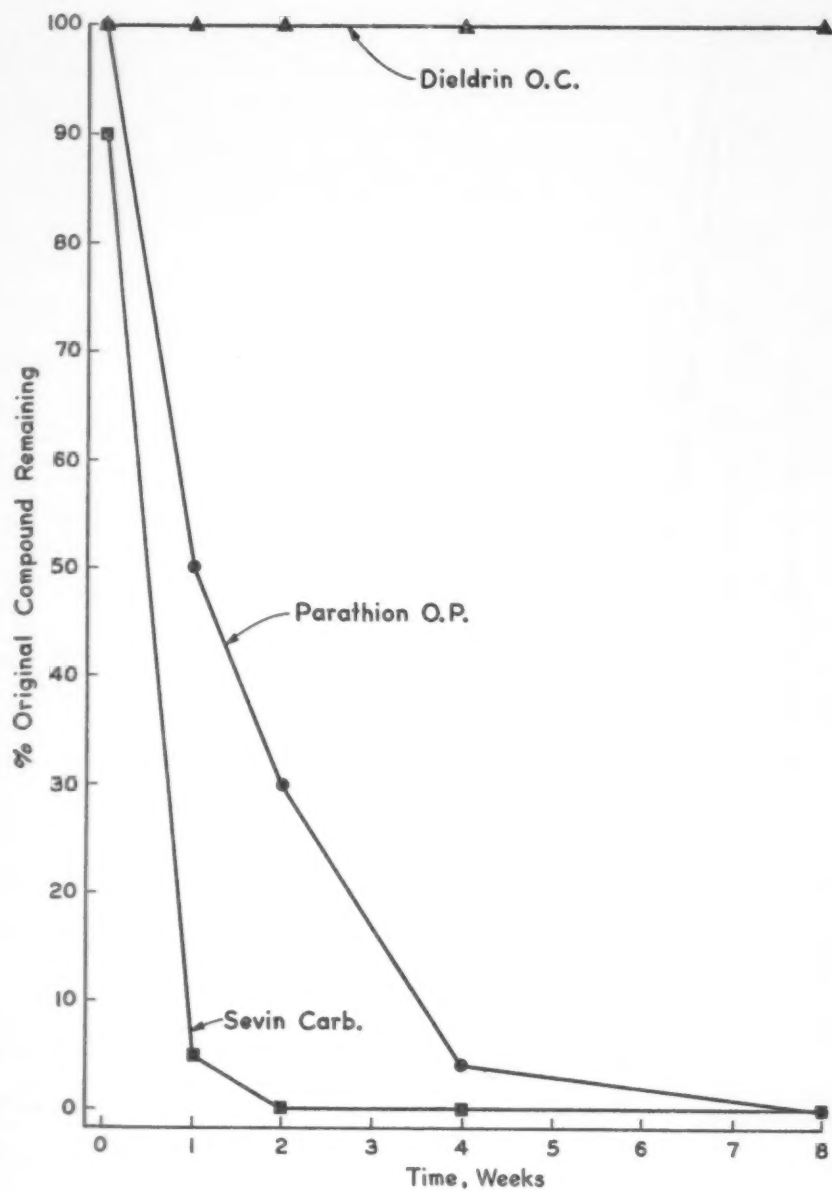


FIGURE 12-D

MEASURED PERSISTENCE
OF PESTICIDES IN
RIVER WATER
COMPARISON OF TYPES

RETA
1025

26-D

Future registration of materials should take these factors into consideration, and promote compounds such as carbamates, which meet these criteria.

Intensive Case Study Area

Information on pesticides in water soils and related ecosystems was gathered through professional contacts. Primary contacts were Dr. Robert Morris of the State Hygienic Lab, Dr. Donald McDonald, Associate Professor of Environmental Engineering and of Preventive Medicine and Environmental Health, Dr. Keith Long, Chief of Environmental Toxicology Section, Institute of Agricultural Medicine and Dr. David Mick, Community Pesticide Studies, Institute of Agricultural Medicine of the University of Iowa, Iowa City.

Dr. McDonald found that pesticides free in water in the Iowa City area generally were in the low parts per trillion (ppt) range, the bottom silts in the parts per billion, and periphyton up to 12 parts per million (22). Aldrin was found in amounts up to 28 ppb in muds during July. DDT was found most frequently in mud, with positive results in 13 out of 19 samples tested. Highest concentrations of pesticides usually occurred in July, August, September, and October following application in May and June as shown in the application section

Figure 8-D). There were no pesticides found in water in November and only trace amounts in January-March.

Cherryholmes (23) made an extensive study of Clear Creek, a tributary entering the Iowa River just below Coralville Reservoir. He found pesticide levels correlated with turbidity, indicating that adsorption is the major transport mechanism. Samples were taken during and after precipitation periods to test the effects of heavy run-off on water quality. Although levels were low (3-37 ppt in water), they were detected only at times of high run-off (2140 CFS) and high turbidity (600 JTU). In contrast, at a flow of 132 CFS, which is still above average, and a turbidity of about 15 JTU, no pesticides were measured.

Metha (24) reported the Iowa River below the Coralville Reservoir had less pesticides than those portions in or above the reservoir during the high pesticide level period of July through September. This may have been due to settling out of sediment in the still water behind the dam. Metha found heptachlor and its metabolites only twice in his study, although it is used widely in Iowa; in a survey by the contractor the estimated 1971 use in the state was 480,000 pounds active.

Appleby (25) studied Iowa sources of dieldrin and

found increases below such point sources as pesticide formulation plants, aldrin-fertilizer blending plants, home bases of aerial applications of aldrin, and wool mothproofing operations with dieldrin. The results of his study are shown in Figure 13-D. He reports an increase in dieldrin in catfish below each of these point sources.

Available data is not sufficient to point to any one source, such as the wool mills at Amana, as the main dieldrin source in Coralville Reservoir. There are many other sources, such as small watersheds, which could contribute to the reservoir; also, the stilling effect of the impoundment and consequential settling out of sediment allow fish and other aquatic forms to be exposed to greater amounts of material.

In the southwest part of the state on the Nishnabotna River, formulation plants do seem to lead to a marked increase in fish levels from 400 ppb above the plants to 1600 below. This same trend is apparent below Des Moines in Red Rock Lake. This situation could warrant a ban on eating catfish in certain regions of the state since these levels exceed the FDA recommended limits. (25)

McDonald also measured pesticides in fish in the Cedar River (26), and Mississippi River (27), water

[illegible]

and fish. Dieldrin is found most often with concentrations of about 3.5 parts per trillion maximum in the water, and fish samples containing about 20 parts per billion with a record peak of 400 ppb.

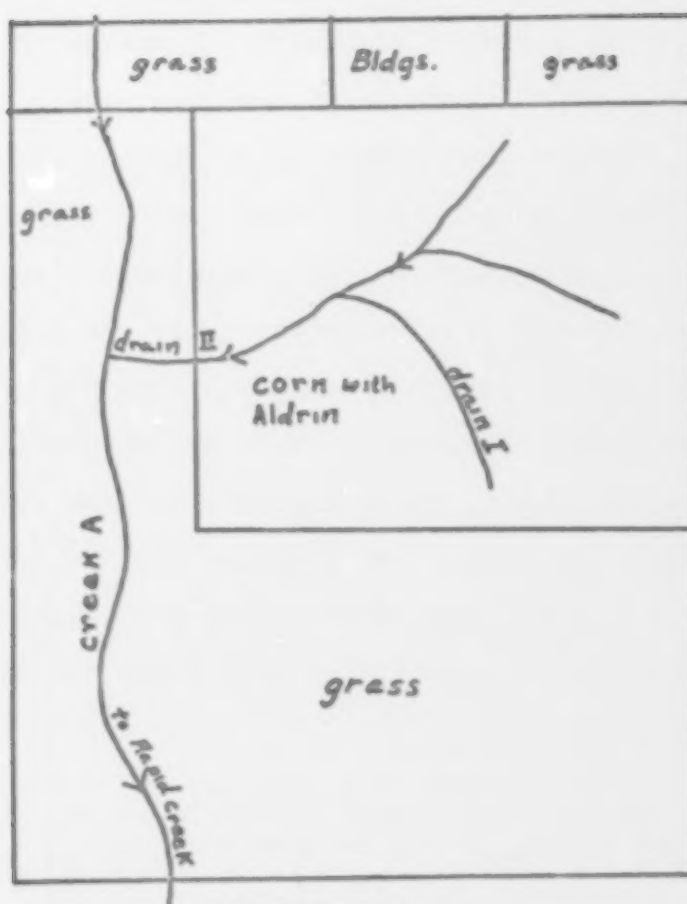
In 1967, Morris (17) studied two farms shown in Figures 14-D and 15-D. Background readings were 0.01 ppb or less. The fields marked were treated with 2 pounds of active ingredient per acre before treatment and planting. After a heavy rain (4 inches in 12 hours) about 1 month later numerous water and sediment samples were taken. Figures shown indicate the amount of pesticide found in run-off. Much of the aldrin applied had been converted to dieldrin by that time; it was assumed that since the diazinon was not detected, it had degraded. Sediments in the water were analyzed and found to contain up to 170 ppb dieldrin.

Morris found that

From the amount of solids and the concentration of aldrin and dieldrin on the solids it can be seen that the total amount of insecticides carried by these solids is about equal to the amount carried by the water.

Even though the concentration of pesticides is much greater in the solids than in the water, the weight of the water is so much greater than that of the solids that the total amounts of pesticides carried by the solids and by water were about equal in samples described in

FARM No. I



Pesticides in Water

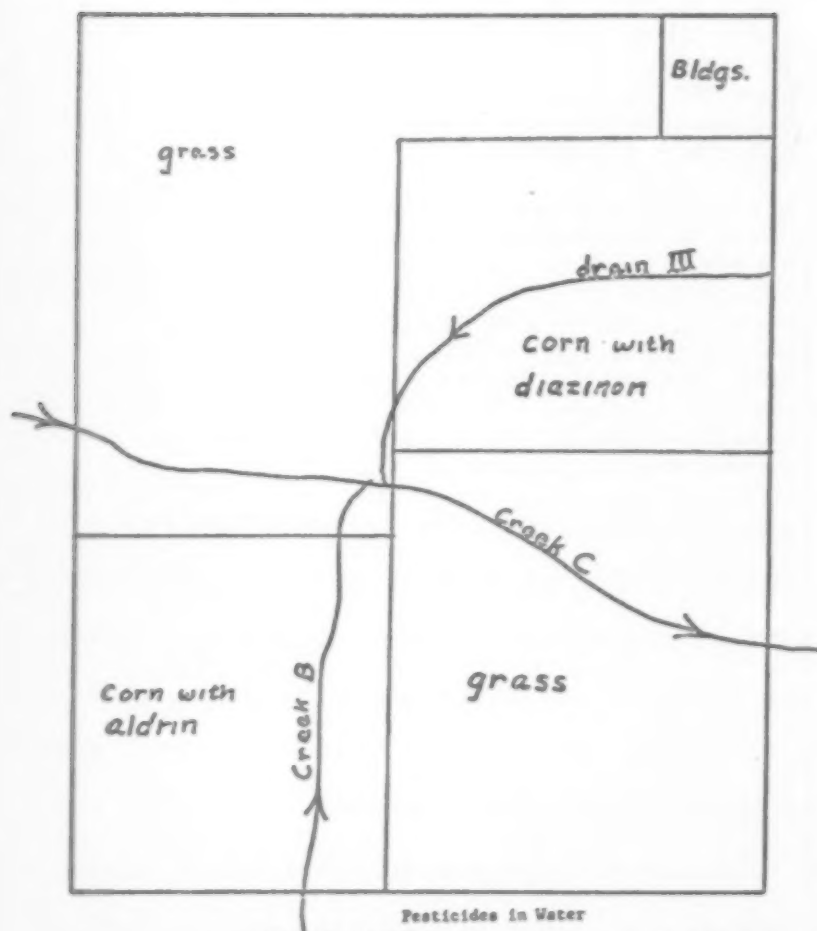
Farm I	Parts Per Billion			Time	Inches of Rainfall
	Dieldrin	Aldrin	Diazinon		
Drain I	0.10	0.02		9:30AM	3
Drain II	0.20	0.06		9:30AM	3
Creek A	0.19	0.06		10:00AM	3
Rapid Creek	0.11	0.04		8:45AM	2.5
Lower River	0.01	*		10:30AM	3.5

* None detected

Pesticides in Solids

Farm I	Parts Per Billion			% Solids
	Dieldrin	Aldrin	Diazinon	
Drain I	143	97		0.22
Drain II	170	120		0.19
Creek A	150	131		0.24
Rapid Creek	65	29		0.16
Lower River	28	13		0.05

FARM No. II



Pesticides in Water

	Parts Per Billion			Time	Inches of Rainfall
	Dieldrin	Aldrin	Diazinon		
<u>Farm II</u>					
Drain III	*	*	*	12 noon	4
Creek B	0.08	0.01	*	12 noon	4
Creek C	0.13	0.06	*	12 noon	4

* None detected

Pesticides in Solids

	Parts Per Billion			% Solids
	Dieldrin	Aldrin	Diazinon	
<u>Farm II</u>				
Drain III	*	*	*	0.28
Creek B	142	137	*	0.10
Creek C	18	2	*	0.27

this report. Possibly some of the insecticides in the water were carried by soil particles which were small enough that they did not settle out in 24 hours.

The data in this report make it clear that pesticide concentration in surface water due to agricultural run-off is much higher in the small streams which are directly fed by the run-off water.

A significant portion of the pesticides are adsorbed on solid soil particles which will settle out on the bottom of the streams and rivers. There the pesticide may be partially desorbed and taken into the water slowly over a long period of time. It will also be slowly degraded to less toxic products over a period of time (17).

The fate of these materials is questionable.

McDonald, Cherryholmes and Metha found only parts per trillion in the Iowa River. In the Mississippi River dieldrin was found in the parts per billion range in 1964, 1965, and 1966 but was not detected in 1967 near the time of Morris' 1967 measurements.

Metha (24) traced some pesticides through algae measurements and found 7800 ppb aldrin, and in one sample 79,000 ppb of chlordane; although dieldrin shows up in water and fish samples, he does not report dieldrin in any of his algae work. Sediment accumulates in the bottom as the water slows down, where algae and bottom feeders pick up the materials. Rough fish and

catfish feed on bottom feeders and the biomagnification chain begins.

These pesticide studies in Iowa have had several effects. One outcome was a law enacted in 1971 limiting soil erosional losses to prevent transport of soil to the waterways. The law encourages better farming practices to prevent soil loss.

There has also been a suggestion that catfish from certain parts of the state not be eaten (25). Perhaps the most striking effect of these studies is the incomplete pesticide picture developed. The work to date has been useful in defining the problem. However, a comprehensive study is needed to examine all factors and routes involved in pesticide operations to determine the significance of pesticides rather than merely their concentrations. Morris (17) (28) concluded that Coralville Reservoir and the Mississippi in Iowa would be good starting places for such a study. He has called pesticide levels in fish a "dismal situation" in Iowa and concludes

Soil erosion must be reduced with all dispatch and immediate toxicants [dieldrin, aldrin] is indicated. . . (in order that) we may still have a sport fishery potential in Iowa (17).

Methods of Disposal of Pesticide Container and Excess Pesticides

One of the biggest potential problems associated with the use of pesticides is the disposal of their containers. At present there is no efficient disposal method. The recommended procedure is to bury them in an area where the pesticides are not likely to leach to ground or surface waters.

Farmers were surveyed to determine disposal methods utilized. Of those responding, 62 percent buried them, and 16 percent disposed of them in the town dump. Twenty percent reported washing containers, presumably for reuse.

All of these disposal practices are potentially dangerous to the environment. Burning containers is recommended by manufacturers, but often the incineration temperature is not high enough to accomplish sufficient degradation. The ash residue may be washed into a stream or pond during spring or summer rainfall. Burying the containers appears to be the least harmful of all disposal techniques, if care is taken to assure that containers are buried where contamination of ground or surface waters cannot result.

Disposal of containers in a town dump has similar drawbacks to burying. Leakage of contaminants other

than pesticides to groundwater is often a problem in landfills. Pesticides disposed of in landfills where leakage occurs can be predicted to contaminate groundwater although this has not been proved. Reuse of containers has obvious harmful effects and farmers are warned against such use by the manufacturers.

Disregard or ignorance by the farmers surveyed of possible environmental damage through container disposal is evident from Table 5-D.

Farm agents in the five state area were asked if they felt manufacturer's instructions for container disposal were understandable and practical (Table 6-D). Most agents responding felt the application instructions were understandable and practical to follow for proper usage. However with regard to applicator's safety the agents agreed the instructions were understandable but were almost evenly divided as to whether instructions were practical to follow. When queried about container disposal instructions, they were divided as to whether the instructions were understandable, but felt strongly that disposal instructions were impractical.

Container disposal continues to be a major environmental problem. Although burning is specifically indicated by most manufacturers, reliable estimates suggest temperatures obtained in open burning are insufficient

TABLE 5-D
METHODS OF DISPOSAL OF PESTICIDE CONTAINERS

Method Used	Illinois	Iowa	Kansas	Minnesota	Missouri
1. Throw in trash for pick-up	14%	20%	22%	26%	17%
2. Burn	65	70	51	85	70
3. Wash and store	40	8	9	17	15
4. Wash and use as container	10	3	11	17	35
5. Dump in ditch or field edge	8	8	13	4	9
6. Bury	12	5	11	9	13
7. Other	24	21	29	9	--

to degrade the residues. Subsequent rainfall would wash residues into the nearest watercourse. Dumping in ditches produce the same result. Some states specifically prohibit (at least in the printed law) the inclusion of containers in trash for pick-up usually destined for sanitary fill. Many municipal dumps or landfills specifically prohibit pesticide containers in the mixed trash, with the possibility of contamination to groundwater supplies often given as a principal reason.

Although burying (with or without specific pre-treatment) is offered as an alternative method by manu-

TABLE 6-D

MANUFACTURERS INSTRUCTIONS ON THE PESTICIDE PACKAGE
AS ASSESSED BY COUNTY AGRICULTURAL AGENTS

State and Problem	Are the instructions clear enough for <u>every-one</u> to understand		Are the instructions <u>practical</u> to follow?	
	YES	NO	YES	NO
<u>Illinois</u> (45) ¹				
Proper Usage	77%	23%	51%	49%
Safety to Man	87	13	49	51
Container Disposal	56	44	43	57
<u>Iowa</u> (47)				
Proper Usage	79	21	79	21
Safety to Man	76	24	53	47
Container Disposal	47	53	35	65
<u>Kansas</u> (41)				
Proper Usage	79	21	75	25
Safety to Man	82	18	68	32
Container Disposal	57	43	36	64
<u>Minnesota</u> (44)				
Proper Usage	71	29	71	29
Safety to Man	77	23	66	34
Container Disposal	45	55	37	63
<u>Missouri</u> (37)				
Proper Usage	70	30	59	41
Safety to Man	62	38	54	46
Container Disposal	35	65	25	75

¹Number in parentheses indicates the number of farm agents contacted in each state.

facturers it is little used by farmers. The reasons most often given are that it is difficult to implement.

A large number of farmers still continue to utilize old containers for general purpose farm pails despite specific warnings against such practices.

There seems to be no economical way to detoxify many of these materials and avoid eventual environmental contamination. Incineration at temperatures in excess of 1625°F should be sufficient to oxidize the compounds at municipal incineration units. A portable incineration unit might be obtained through a pesticide tax to collect containers and dispose of the material property. Sufficient information is available on the success of portable (29) or fixed incinerators (30) to warrant further research in this area, including a thorough study of the transportation and materials handling aspects of the problem.

Monitoring Data

Measurement of pesticide levels in water or sediment or the speed with which these materials move down a watershed is difficult due to a lack of data. Sample analysis is costly, and there are not many places where measurements are made throughout a watershed. Many mea-

surements are made on a three or six month schedule; no additional effort is made to measure pesticides during peak flow conditions which coincide with periods of maximum pesticide concentration. Some measuring periods skip the June sample, which Figure 8-D (see Chapter 3) shows as the most likely time to encounter pesticides. Bills currently before Congress (HR56, S681), would set up a National Environmental Data Bank to allow better access to collected information. Despite opposition to the bill by the Council on Environmental Quality and Environmental Protection Agency, its sponsors feel current operations do not allow for efficient retrieval of information.

Congressmann John D. Dingel (D-Mich.), author of HR 56, said he was appalled at the amount of money spent on research that is poorly organized and stored, and which is difficult to retrieve.

He said there already is a vast amount of useful information stored in federal files "in essentially unretrieval form" and noted that the amount of this material will increase within a few years. A system to reduce the amount of information that would have to be reproduced and distributed would reduce the administrative burden on the Government and result in substantial savings, he contended. (31)

Most analytical data is stored in STORET, a data retrieval system containing all Federal analytical

work as well as some state and private information. However non-federal inputs to STORET are voluntary and often not made due to lack of money or personnel.

STORET does contain some data on water measurement from the stations shown on Figure 16-D, but major drawbacks to the collection system negates the value of these data. Table 7-D shows all STORET data (32) on pesticides for selected stations along the main-stream of the Mississippi, Missouri, and Kansas Rivers. Sampling dates used do not facilitate the tracing of pesticides downstream nor the location of pesticide sources. It is possible to infer that the Kansas River contributed herbicides to the Missouri River since herbicides were detected in the Missouri below the mouth of the Kansas in 1969 and 1970, but not above the mouth in 1970 or 1971, and they were detected at Topeka, Kansas in 1969 and 1970. But because no measurements were made above the Kansas for the same period it is not possible to certify that the herbicide source is the Kansas River.

There are almost no values reported for sediment which might help answer questions about pesticides carried by this transport method.

Pesticide monitoring is vital to increase knowledge about this source of potential danger to man.



FIGURE 16-D
STORET DATA POINT LOCATIONS

- ⊕ Reported in Table 7-D
▲ Not Reported in Table 7-D

Table 7-D

TYPICAL MONITORING DATA FROM STORET SYSTEM
LOWER MISSOURI RIVER

Sampling Location & Date	Aldrin ug/l	BHC ug/l	Chloro- dane ug/l	DDD ug/l	DDE ug/l	DDT ug/l	Pesticide Compound					H-Para- thion ug/l	2,4-D 2,4,5-T ug/l	Silvex ug/l
							HCHLR	Endrin	HCHLR	EP	Malathion	thion		
							ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Omaha, Nebr. 3/9/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E
Nebraska City, Nebr. 9/17/70	0.000E	0.000E	0.000E	0.010E	0.000E	0.010E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E
2/11/71	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E
3/16/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.010E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E
4/8/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E
St. Joseph, Mo. 3/9/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.070E	0.000E
Miami, Mo. 10/21/69	0.000E	0.000E	--	0.000E	0.000E	0.010E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.060E	0.010E
3/10/70	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.110E	0.000E
--	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.110E	0.000E
5/20/70	0.030E	0.000E	0.000E	0.000E	0.000E	0.020E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.030E	0.050E
Herman, Mo. 10/21/69	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.020E	0.060E
2/26/70	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.120E	0.030E
5/26/70	0.010E	0.000E	0.000E	0.000E	0.000E	0.020E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.040E	0.040E
8/18/70	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.000E	0.000E
12/29/70	0.000E	0.000E	0.000E	0.000E	0.000E	0.010E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.000E	0.370E
3/16/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.060E	0.090E
St. Louis, Mo. 3/12/71	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.060E	0.040E
Kansas River at Topeka, Kansas 12/11/69	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.000E	0.020E
3/17/70	0.000E	0.000E	--	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	0.000E	--	0.000E	0.010E
6/12/70	0.000E	0.000E	0.020E	0.010E	0.000E	0.020E	0.010E	0.000E	0.000E	0.000E	0.000E	--	0.580E	0.150E

Table 8-D

TYPICAL MONITORING DATA FROM STORET SYSTEM
MISSISSIPPI MAINSTEM - MOST RECENT DATA

Sampling Location & Date	Aldrin ug/l	BHC ug/l	Chloro- dane ug/l	DDD ug/l	DDE ug/l	DDT ug/l	Dieldrin ug/l	Endrin ug/l	Pesticide Compound			M-Para- thion ug/l	2,4-D 2,4,5-T ug/l ug/l		Silvex ug/l
									HCHLR EP ug/l	Malathion ug/l	Para- thion ug/l				
Below St. Paul 11/3-11/10/64	0.000	0.000	--	0.000	0.000	0.000	0.000N	0.000	0.000	0.000	0.000				
9/22/65	0.000	0.000	--	0.000	0.000	0.000	0.000N	0.000	0.000	0.000	0.000				
9/13/66	0.000	0.012	0.000	0.600	0.000	0.000	0.000	0.000	0.000	0.000	0.004				
9/29/67	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
Dubuque, Iowa 9/23/64	0.000N	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
9/23/65	0.000	0.000	--	0.000	0.000	0.000	0.000	0.024	0.000	0.048	0.067				
9/13/66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.000				
10/2/67	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
Burlington, Iowa 9/23/64	0.000	0.000	--	0.000	0.000N	0.000N	0.004	0.004	0.000	0.000	0.000				
9/22/65	0.000	0.000	--	0.000	0.000	0.000	0.000	0.009	0.000	0.000N	0.000N				
9/13/66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000				
9/29/67	0.000	0.000	--	0.900	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
East St. Louis, Ill. 9/23/64	0.000	0.000	--	0.000	0.000	0.000	0.000N	0.000N	0.000	0.000N	0.000				
9/22/65	0.000	0.000	--	0.000	0.000	0.000	0.000N	0.005	0.000	0.000	0.000				
9/13/66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000N	0.000	0.000	0.000				
9/29/67	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
Cape Girardeau, Mo. 9/23/64	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000N	0.000				
9/22/65	0.000	0.000	--	0.000	0.000	0.000	0.000N	0.005	0.000	0.000	0.000				
9/13/66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000N	0.000	0.000	0.000				
9/29/67	0.000	0.000	--	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				

Z = Composite lab sample
M = Presumptive evidence of material

However, haphazard monitoring such as now exists is not the key. Nor will a program such as that proposed by Feltz, et al. in the Pesticide Monitoring Journal, (33) - quarterly water measurement and semi-annual sediment measurements at 161 U. S. stations - provide the necessary answers. The contractor feels that this would be a fruitless effort. A series of intense studies, supplemented by daily data from water intakes of large cities on major waterways would be of vital importance. This program is detailed in the recommendations section of this chapter.

Summary and Conclusion

Pesticides may enter the water environment through many routes from its point of application. A primary transport mechanism is adsorption onto soil particles which, during erosion are subsequently moved in water as sediment. Due to the low solubility of most pesticides in water they do not dissolve to any great extent. Some materials, especially derivatives of some herbicides, are slightly soluble, and the resulting solution can become a significant transport mechanism. The total quantity of herbicides moved by water has been shown to be equal to the amount moved on sediment because of the greater amount of water in relation to the amount of

sediment involved in transport.

Drift from spray application was limited in significance due to relatively short distances the drifting material travels before it settles to the ground. The distances are usually no more than 1/2 mile downwind, and no further than the edge of the field under upwind application. Drift does become a problem when a body of open water lies near the application field.

Loss to the atmosphere through drift and mist can be significant and has been measured at 25 percent of the amount applied. Evaporation may amount to 2 to 3 percent of the amount of pesticides applied, with moisture content of the soil greatly influencing the size of this contribution.

Since pesticides are easily adsorbed into the soil, they usually do not penetrate to ground water unless a fissure or crack exists allowing surface water to flow directly into ground water.

A great potential for pollution does exist when empty pesticide containers are not properly disposed. However, thus far no effective means of disposal has been developed.

Agricultural practices can reduce erosion losses to a minimum, and could be a most effective means of preventing pesticides from entering the aquatic environment.

Pesticide monitoring presently consists of haphazard, disorganized data collection. The current program does not detect pesticides at concentrations greater than a few parts per trillion, levels which 10 years ago were undetectable by most techniques and levels which have not been shown to be harmful to man.

A comprehensive data collection system sensitive to the parameters influencing pesticide movement - runoff and sediment and weather conditions - must be developed. The contractor proposes in the recommendations section of this report a series of intensive study areas in small watersheds supplemented by daily measurement of pesticides from large municipal water treatment plants on major rivers.

Recommendations

From this investigation it is clear that water contamination by pesticides will be minimized when farm field erosion is reduced. Practices such as contour plowing and minimum tillage help slow erosion, but fall plowing and plowing to the edge of a field may produce large amounts of sediment. Several practices can reduce sediment transport of pesticides:

1. Elimination of fall plowing, which exposes broken soil to winter storms and spring run-off.

2. Leaving a barrier strip around field edges for sediment basins to catch sediment from fields. An area plowed but left unharrowed and unplanted would slow down run-off and allow at least a portion of the sediment to settle.
3. Construction of large sedimentation basins to catch run-off from several fields, with provisions to mechanically remove sediment after each storm and retruck it to fields or land-banked areas for deposit. This system would "recycle" soil and prevent loss from the area, with resultant savings to the farmer and to those who must keep navigation channels open and water impoundments functions.
4. Investigation of the plowing scheme, ridge plowing described by Ritter (20) which reduced erosion and pesticide losses by a factor of 7 times. (5) A series of extensively monitored typical basins would provide better understanding of the route of pesticides to water and their potential harm. Weekly water and sediment monitoring of a small basin of about 100 square miles will provide background data to be supplemented

by more frequent samples during periods of high water flow or rainfall. Meteorological data, continuous flow and turbidity measurements, and sedimentation rates could be compiled to study the effects of different farming practices. Pesticides inventories and soil pesticide measurements could also be established.

If a 10 to 20 basin system could be implemented, one could more effectively evaluate the effect of pesticides in the water than would be possible in the larger network on a time basis proposed by Feltz.

LITERATURE REFERENCE

- 1 Fehrenbacher, J. P., G. O. Walker, and H. L. Wascher, Soils of Illinois, University of Illinois Agricultural Experiment Station Bulletin 725, 1967.
- 2 Shell Chemical Company, Technical Data Bulletin, Summary of Basic Data for Technical Aldrin, 1968.
- 3 Shell Chemical Company, Technical Data Bulletin, Summary of Basic Data for Technical Dieldrin, 1971.
- 4 Geigy Agricultural Chemicals, Aatrey Herbicide Technical Bulletin, CIBA-Geigy Corporation, 1971.
- 5 Smith, D. D. and L. H. Wischmeier, "Rainfall Erosion", Advances in Agronomy, 14, 109 (1956).
- 6 U. S. Geological Survey, Water Resources Data for: Iowa, Minnesota, Missouri, Kansas, U.S.G.S., 1970.
- 7 Taylor, A. W., "The Measurement of Pesticide Persistence in Soils," 162nd ACS Meeting, Washington, D. C., 9/71.
- 8 U.S.D.A., National Soils Monitoring Program, Laboratory Analysis Report - Soil O-6", for Illinois, Iowa, Missouri, Fiscal Year 1969.
- 9 Morris, R. L., L. G. Johnson, Pesticide Levels in Fish and Bottom Silts from Iowa Streams, Report #71-10, State Hygienic Laboratory, University of Iowa, Iowa City, Iowa, 1970.
- 10 Jager, K. W., Aldrin, Dieldrin, Endrin and Telodrin, Elsevier Publishing Company, Amsterdam, New York, 1970.
- 11 Martin, W. P., W. E. Fenster and L. D. Hanson, Fertilizer Management for Pollution Control in Agricultural Practices and Water Quality, ed. Willrich, T. L., and G. E. Smith, Iowa State University Press, Ames, Iowa, 1970.
- 12 Adams, R. S., Jr., and L. Paulina, "Soil Properties Influencing Sorption and Desorption of Lindame", Soil Science Society of America Proceedings, 35, 78 (1971).

- 13 Martin, W. P. and R. S. Adams, "Soil Pollutants and Their Effects in Agriculture", 19th Annual Meeting of Agricultural Research Institute, National Academy of Sciences, 1970.
- 14 Oschwald, W. R., "Erosion and Sedimentation as Causes of Pollution", Illinois Research, 12, 12 (1970).
- 15 Harrold, L. L., Research on Agricultural Pollution in Ohio, USDA Agricultural Research Service, Soil and Water Conservation Research Division, Coshocton, Ohio, 1971.
- 16 Caro, J. H. and A. W. Taylor, "Pathways of Loss of Dieldrin from Soils Under Field Conditions", Agricultural and Food Chemistry, 192, 379 (1971).
- 17 Morris, R. L, L. G. Johnson, and W. Patton, Some Aspects of Pesticides in the Iowa Environment, Report 70-10, Iowa State Hygienic Laboratory, University of Iowa, Iowa City, Iowa, 1969.
- 18 Spencer, W. F., "Distribution of Pesticides between Soil, Water, and Air," Pesticides in the Soil, Michigan State University, East Lansing, Michigan, 1970.
- 19 Frost, K. R. and G. W. Ware, "Pesticide Drift from Aerial and Ground Applications," Agricultural Engineering, 51, 460 (1970).
- 20 Ritter, F. R., Environmental Factors Affecting the Movement of Atrazine, Propachlor, and Diazinon in Ida Silt Loam, Ph.D. Dissertation, Iowa State University, Ames, Iowa, 1971.
- 21 Eichelberger, J.W. and J. J. Lichtenberg, "Persistence of Pesticides in River Water," Environmental Science and Technology, 5, 541 (1971).
- 22 McDonald, D. B., Personal Communication, 1971.
- 23 Cherryholmes, K. L., The Effects of Agricultural Land Runoff on the Limnology of Clear Creek, Master's Thesis, University of Iowa, Iowa City, Iowa, 1970.

- 24 Metha, S. C., Limnological Factors Affecting Pesticide Residues in the Iowa River and Coralville Reservoir, University of Iowa, M. S. Thesis, Iowa City, Iowa, 1969.
- 25 Appleby, W. G., Sources of Dieldrin Residues in Iowa Fish and Waterways, Shell Chemical Company, 1971.
- 26 McDonald, D. B., DAEC Cedar River Water Quality Study Quarterly Report, Summer 1971.
- 27 McDonald, D. B., Personal Correspondence, 1971.
- 28 Morris, R. L. and L. G. Johnson, Pesticide Levels in Fish and Bottom Streams from Iowa Streams, Report 71-10, Iowa State Hygienic Laboratory, University of Iowa, Iowa City, Iowa, 1970.
- 29 Danielson, J. A., Air Pollution Engineering Manual, U.S. Public Health Service NCAPC, Cincinnati, Ohio, 1967.
- 30 Shuman, S. L., Jr., B. J. Stojanovic, and M. V. Kennedy, "Engineering Aspects of the Disposal of Unused Pesticides, Pesticide Wastes, and Pesticide Containers," J. Environmental Quality 1, 68 (1971).
- 31 BNA Current Events, 2, 887 (1971).
- 32 EPA, Storet Data (Pesticides for 5 states in study area), 1971.
- 33 Feltz, H. R., W. T. Sayers, and H. P. Nicholson, "National Monitoring Program for the Assessment of Pesticide Residues in Water," Pesticides Monitoring Journal, 5, 54 (1971).

APPENDIX E

IMPACT ON THE AQUATIC ENVIRONMENT

Introduction

The dilemma of pesticides is that they do so much good and yet threaten so much harm. (1) The relative good and harm have been the subjects of considerable numbers of review papers in the literature, governmental hearings, public outcry, popular press, mountains of scientific papers and a phenomenal quantity of good substantial scientific investigation as well as notorious misinformation, distorted truths, and gaping voids in our total understanding of the use and fate of these compounds.

The entire problem, especially that of the aquatic environment, was summed up quite well by Johnson (2) who, quoting Surber(1948) states that "studies of the effects of pesticides on fish, on their food, and on various forms of wildlife are proceeding along operational lines. From an ecological standpoint, this seems an ideal method of approach, as all implications of the operations may be viewed in their entirety." Unfortunately (states Johnson), progress in the last eighteen years (now 23 years) seems to indicate that "operational lines" have not been as effective as was hoped.

Scandinavian researchers tried to alert the world population to the potential danger of high residue levels of DDT and its metabolites and dieldrin in food supplies in the early fifties - warnings that went largely unheeded. National recognition of the real potential for harm came to the United States in 1962 with the prediction of SILENT SPRING by Carson (3). While both deservedly applauded and denied by different segments of society, the book did, nevertheless, have a profound impact on public thinking.

An alert and aroused public could see the results of overt misuse (overuse) of compounds which, following massive applications, left untold numbers of dead and dying fish and wildlife species across the lands and waters of the country. This same public was and still is, unfortunately, quite naive about parts per thousand, million or trillion or nannogram or picogram quantities. It is precisely these small, persistent and ever accumulating quantities to which we must address ourselves.

This task assignment will not be presented as a complete literature review -- such a review would constitute a needless restatement of the problem already covered by many thoroughly competent scientists around the globe. It does, however, seek to identify and discuss those areas, which in our opinion, deserve thoughtful consideration and in which major research emphasis

should probably be directed in the next several decades.

There is a definite scarcity of hard data in the literature for biological responses to aldrin, dieldrin or atrazine. While a copious literature exists for DDT and related products the story which we have pieced together for dieldrin is the result of isolated fragments and similarly related environments and their flora and fauna. Much of this section then, is largely interpretive with many of the conclusions resulting from inference.

We are somewhat blessed by the Iowa Community Pesticide and related State Hygienic Laboratory activities in Iowa and the Federal Fish-Pesticide Research Laboratory in Columbia, Missouri. The inclusion of data from other (often remote) sources is deemed justified when it demonstrates a particular point.

The Aquatic Ecosystem

A thorough understanding of trophic structure and trophic level dynamics is still wanting. An appreciation of the complexity of trying to understand the effects of a foreign chemical when applied to any natural, living system when we are really only at the threshold of understanding of the system itself should be obvious.

One primary requirement for all of us seems to be that we stop looking at our own often petty, vested

interests and begin to view the global implications of our acts. The agricultural use of pesticides to insure a continued high yield of high quality food and fiber is not at issue and is viewed by most rational men as necessary to a vibrant productive agriculture. What is at issue is the kinds of products used, the quantities applied and an implementation of practices which will insure minimum damage to our fragile environment.

Although some studies have been conducted on basic physiological responses of fishes and pesticides, such studies are largely lacking from invertebrate animals. The oyster and some few other commercially valuable species are exceptions. That these other animals are vital links in the chain of concentration of pesticides residue has been amply demonstrated. The point which should be made, perhaps, is that basic physiology -- especially as it relates to growth and population dynamics, may be the most important feature. The good health of any food chain or trophic structure rests on the good health and perpetuation of any individual trophic level. Thus, we believe that more fundamental experiments should be instituted to determine the long range effects of sub-lethal exposure on basic invertebrate groups, especially as such exposure relates to intrinsic rates of natural

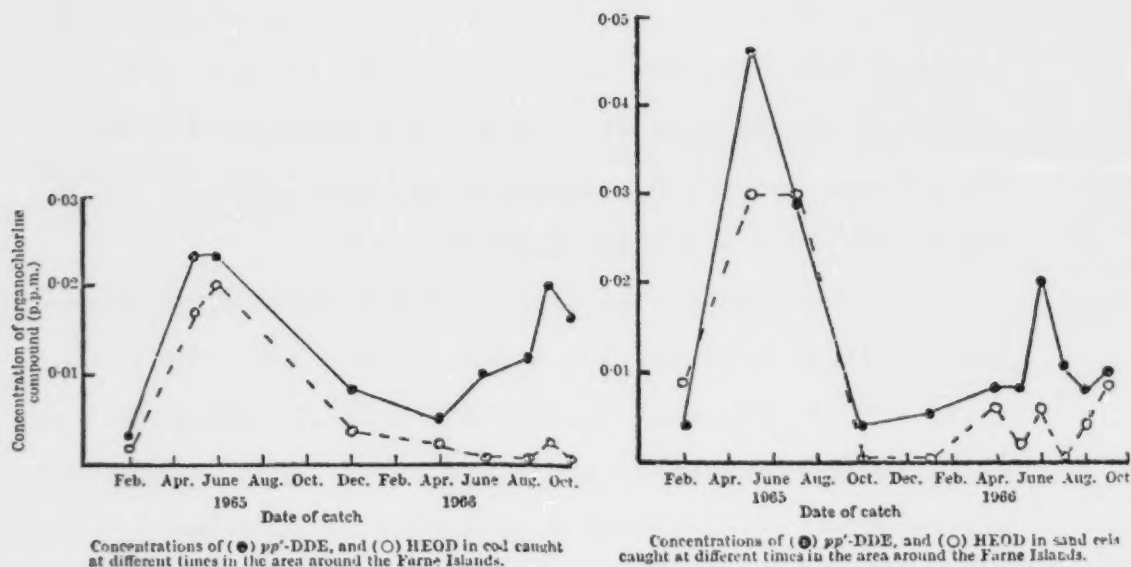
increase. Unfortunately we know relatively little about the basic physiology of these organisms, let alone their population dynamics.

Fundamental to our discussion and directly relevant to the different organo-chloride compounds is the question of whether other compounds (i.e. cyclo-dienes) follow the picture of distribution observed in the much more widely examined family of DDT and it's residues. Such data is presented by Robinson et al (4) and dramatically shows the intimacy of the relationship between dieldrin (HEOD) and pp'DDE in two fishes (Figure 1-E).

Of equal impact, we think, is the seasonal picture demonstrated; a winter low and a summer high. This source variation is reflected in the 1965 data for concentrations of these two compounds in the egg of the shag, Phalacrocorax aristotelis, which showed a considerable increase in concentrations as the egg laying season progressed, (Figure 2-E). Thus, the increasing quantities in their food (the fish) reflected in the increasing quantities in eggs. Data for 1964 showed a decrease, which could easily reflect data of the kind seen for fish for the year 1966. (Figure 1-E), especially during the period when egg material is being metabolized.

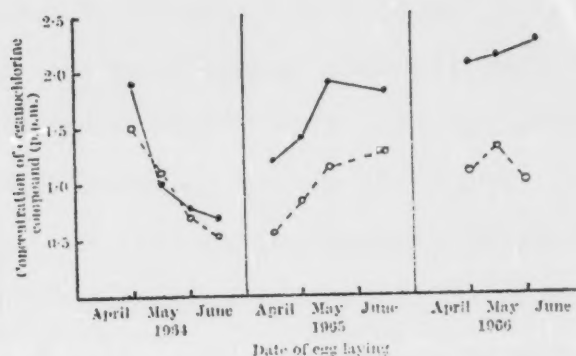
Figure 1-E

COMPARISON OF CONCENTRATIONS OF DDT AND
DIELDRIN (HEOD) IN TWO DIFFERENT FISH



Several additional points are made which deserve our attention. The suggestion is made that the concentration of pesticide in birds is in equilibrium between intake and excretion (and metabolism) of insecticide residues. Thus, if the rate of metabolism and excretion is greater in certain vertebrates than in invertebrates or food of the next trophic level, no concentration or

Figure 2-E
CONCENTRATION OF ORGANOCHLORINE COMPOUNDS IN SHAGS'
EGGS LAID AT DIFFERENT TIMES. 0,pp'-DDE; 0, HEOD.



biological amplification would be seen. One assumes that the reverse is true in some, but not all, food chains, since many examples are seen which indicate a progressive accumulation and concentration up the food chain or trophic level.

Clearly much additional research is necessary to identify the fate of parent compounds and residues at each trophic level. This is particularly true as it relates to the rate of turnover of the compounds.

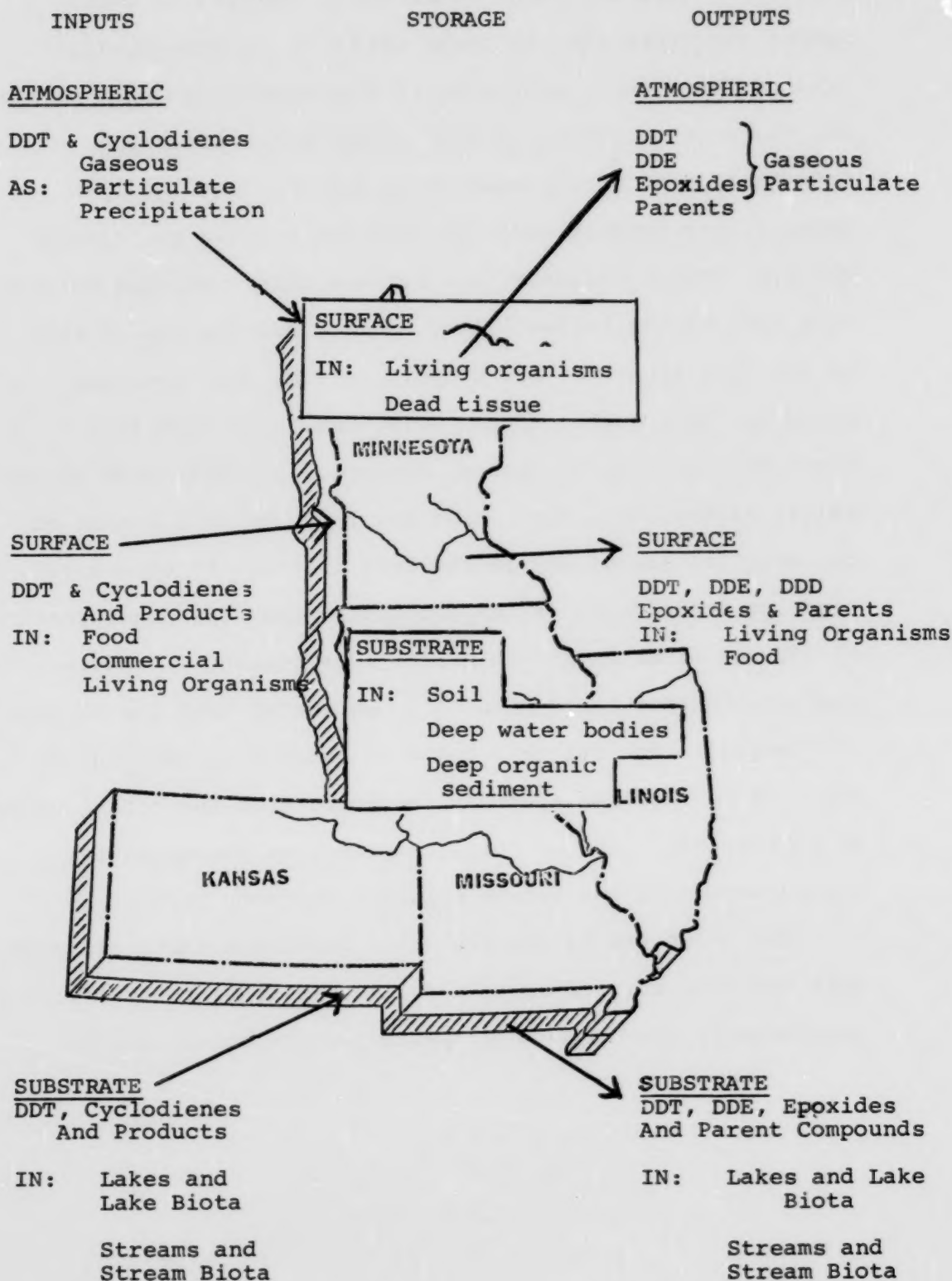
A step in the right direction is seen in the recent work of Metcalf and co-workers (5). The model eco-system they propose could be very useful in relatively rapid screening tests of large numbers of compounds as well as identifying the fate and chemical nature of metabolites. We feel that the worth of such an approach could be improved

tremendously if all levels were investigated (i.e.) bacteria, fungus, protozoans, etc.)

We have taken the liberty of modifying the presentation of Harrison, et al (6), Figure 3-E and presenting in graphic form the fate of DDT compounds and other chlorinated hydrocarbons. This figure helps bring the study area into focus. It should be remembered that each of the compartments; atmosphere, surface and substrate, each contribute to the larger global environment. Contributions to the substrate component streams are seen as contributing to the larger streams (Missouri, Illinois, Mississippi), thence to the delta and estuarine areas, the Gulf, Caribbean Sea and finally, the high seas. Such a sophisticated modeling of a natural system is absolutely essential to future calculations of the fate of compounds added to and persistent in the environment. This study points up the low solubility in water, high solubility in lakes and high stability of the organo-chlorides in living tissue, features which allow magnification of these compounds from lower to higher trophic levels within an ecosystem.

Studies of this kind are also valuable in that they show us, mathematically, features about age distribution,

Figure 3-E
FATE OF CHLORINATED HYDROCARBONS IN THE FIVE STATE STUDY AREA



generation time and other demographic features of population structure and how these relate to systems equilibrium. Thus, their estimates (for Lake Michigan ecosystems) for the time necessary to reach equilibrium after the introduction of organo-chlorides, depends upon the life spans in the trophic structure and the various age distributions. Their estimates lie between four times the average life span of the longest-lived species and the sum of all of the life spans for all trophic levels. It is easily possible, they conclude, that ecosystems with such long lived constituents as eagles, ospreys, and gulls (and whales, seals, walrus, etc. etc.) have not felt the full impact of the original use of DDT in the late 1940's. Of even more sobering consequence is the prediction that the concentration of DDT and other organo-chlorides once present in obliterated populations would then be concentrated into the remaining species. How far this could be carried is doubtful to say. It does become apparent, however, that the consequences of present additions of these compounds on the worldwide environment will not become apparent for many years.

Eberhardt and co-workers (7) point out that, although much has been written about modeling, we possess insufficient knowledge of the kinetics of pesticides in ecosystems to

complete these models. Utilizing radiolabeled compounds, these workers have identified slow and fast compartments; fast compartments representing transient conditions when the concentration of pesticide in the water was relatively high, and slow compartments, such as long term retention as might be accumulated through the food chain. The contractor feels that the concept has important ramifications since so many of the acute or chronic studies completed in the past have failed to identify the rates and routes by which pesticides were accumulated or retained. Although not stated (7) it would appear to us that any gilled animal or any vertebrate with a moist skin (like frogs) could possess both a fast and slow compartment, neither of which are very well documented for the mass of animals which have been studied so far.

What Kinds of Evidence are there that Pesticides do Accumulate and Concentrate?

The only study which might demonstrate a natural bio-accumulation in the five state study area is some of the work of the Iowa Community Pesticide Study. Unfortunately, much of this data collection is fragmentary and the residue analysis devoted to something other than a complete ecological analysis. Although more thorough ecosystem analysis is contemplated, at present the experiments either have not been completed

or previously gathered data has not been analyzed.

Studies of several of the rivers and reservoirs in Iowa suggest that agricultural runoff is considerable and that residues, particularly of dieldrin, are close to, or exceed, the FDA action guideline of 300 ppb. Samplings of water, muds, fish and fish eggs have been conducted and analyzed for organo-chlorine residues. A number of points are in order.

The reports of the State Hygienic Laboratory (8) are regarded as rather naive in their presentation. Often species names are omitted, dates of couple collections are not presented and age and/or size is often omitted. It is clear, however, that many species of fishes from instate water are carrying heavy body burdens of DDT and its metabolites as well as dieldrin and other organo-chlorides. Bottom dwelling feeding species in general carry higher residues than carnivorous species. An interesting point is that the eggs of the bullhead (no species given) are much lower than other species. We interpret this to suggest that transovarian movement of pesticides is much less marked in this bottom feeding species than in other insectivorous or piscivorous

fishes. Unfortunately no data for channel catfish eggs is presented -- this may be a characteristic of the family.

The identification of foods eaten and the relative contribution of these foods to the total body load of pesticides is regarded by us as highly desirable and a serious shortcoming of these studies at present. (9, 10)

Graduate studies sponsored by the project tend to support other studies and do present seasonal data. An increase in residue from water to mud to algae to fish is also indicated. Dieldrin was the most frequently occurring pesticide found in fish flesh as well as the most highly concentrated residue.

Some interesting recent data collected by Mc Donald (11) is presented to demonstrate rather dramatically, we think, the extreme variability and consequently the difficulty encountered in trying to make meaningful interpretations of water, muds or biological samples. Tables 1-E, 2-E, and 8-E Figure 4-E . The data for dieldrin at stations 1-4 appear to reflect the river hydrodynamics; main channel values lower (tr) than near shore values (3.0, 1.5) or running slough (2.0) This may mean then, sediments which carried a heavy load of absorbed residue and were deposited in

TABLE 1-E

LEVELS OF DIELDRIN FOR WATER, SEDIMENT
AND PERIPHYTON, MISSISSIPPI RIVER - 1971*

Station	Water pptr	LOCATION	
		Sediment ppb	Periphyton ppb
1	3.0 (4 Aug)	tr	.20 (4 Aug)
2	1.5 "		
3	2.0 "		
4	tr (8 Sept)	.053, 7.2 Aldrin	.09 " (1.0, 18 Aug)
5	1.6 (4 Aug)		
6	1.2 " (3.6, 22 Sept)		
9	.6 (4 Aug)	0.23 (ca 1.0, 18 Aug)	.24 (4 Aug) (2.8, 18 Aug)
		tr	.10 (4 Aug) (1.0, 18 Aug)

* See Location Map, Figure

I O W A
CLINTON COUNTY

Figure 4-E
MAP OF SAMPLE LOCATIONS, WATER,
SEDIMENT, PERIPHYTON



these locations, now are in some kind of equilibrium with the water there.

It is also dramatically shown that rainfall and subsequent discharge from the land resulted in transitory three fold increase in water (1.2 to 3.6 pptr.) on or about the 10th to 18th of August. Such a rise in water is reflected in a ten fold increase in periphyton levels .10 to 1.0 ppb. This example serves, we feel, to emphasize the necessity for mobile non-time based monitoring as is currently practiced or anticipated. It is vitally important that measurements be made when biological events are occurring, not by the calendar.

This data on periphyton residue valves from different water areas presents to us a very interesting picture of the potential for accumulation with reduced water flow table.

The most significant ecological feature of this and the water and sediment data, is the fact that these shallow areas (1,2,5,6) or reduced flow areas (closed slough, back-water) which carry the highest residues, are the areas which warm the fastest (and as a result, speed biological processes) and are consequently used as nursery grounds for young invertebrates and fishes alike. Since most younger animals are considerably less tolerant of pesti-

TABLE 2 - E

CONCENTRATION OF DIELDRIN IN PERIPHYTON, MISSISSIPPI RIVER

13 May 1971

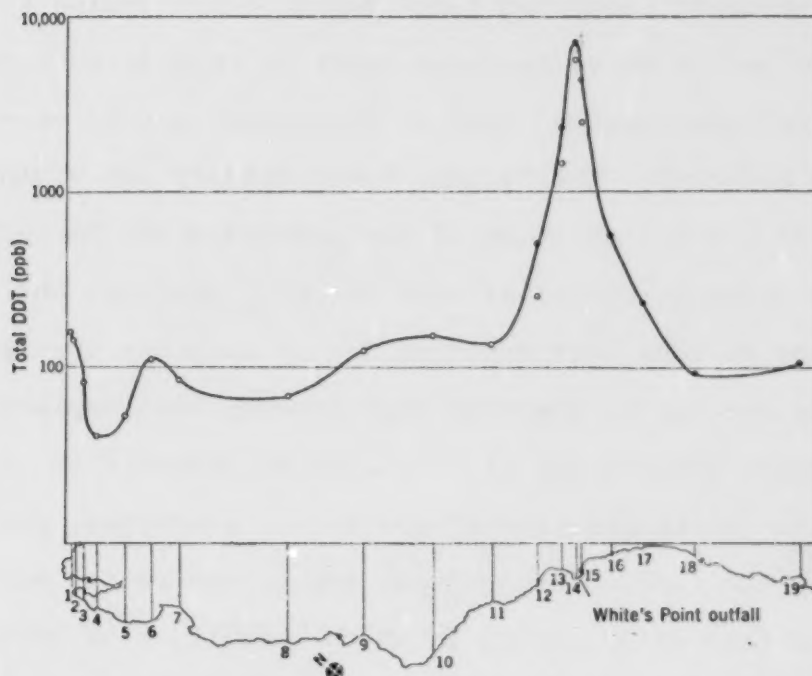
Water Condition	Dieldrin ppb.	Approx. Concentration over water at 20 ppb.
Running Slough	2.4	1000X
Side Channel (up)	2.0	
Closed Slough	3.8	
Side Channel (down)	1.4	
Backwater	12.1	6000X

cides than adults of the same species, the combination is particularly devastating. Thus, the juxtaposition of young organisms, high residues, and speeded metabolism, is viewed as potentially very damaging to aquatic food chains at all levels.

The subject of the contamination of ecological cycles has been covered extensively by numerous excellent test treatments and review articles (12, 13, 14, 15, 16 and 17). Several examples will serve to demonstrate that additions of these compounds made in inland waters do find their way downstream to bays, estuaries and the seas. Thus, examination of body levels of DDT in the sand crabs Emerita analoga from nineteen California beaches apparently shows that additions of DDT at one point along the coast give the observed results (18). Sediments near the outfall are estimated to contain over 100 metric tons of total DDT as a potential reservoir for inclusion into marine food chains. It is interesting that interpretation of possible point sources of contamination leads this author to conclude that historically additions of DDT could be attributed to a significant degree to industrial waste discharge in addition to extensive agricultural usage (Figure 5-E). Although not directly comparable, the accumulation of DDT

Figure 5 - E

LOCATION AND CONCENTRATION OF DDT AND RESIDUES ALONG CALIFORNIA COAST AND IN SAND CRAB



Plot of mean concentrations in parts per billion (ppb) (wet weight) of DDT in *Emerita analoga* at various locations along the California coast. (Open circles) Samples collected in November 1970; (solid circles) samples collected in February 1971. The curve is a freehand interpolation between points.

Mean concentrations ($\bar{X}$) and standard error (S.E.) in parts per billion (wet weight) of DDT, DDD, and DDE in *Emerita analoga* for given latitudes along the California coast. N, animals collected in November 1970; F, animals collected in February 1971.

Station	Latitude	DDT		DDE		DDD	
		No.	$\bar{X} \pm \text{S.E.}$	No.	$\bar{X} \pm \text{S.E.}$	No.	$\bar{X} \pm \text{S.E.}$
1 N	37°48'	8	69. $\pm$ 13.	7	69. $\pm$ 13.	7	19. $\pm$ 4.
2 N	37°46'	8	74. $\pm$ 8.	6	51. $\pm$ 7.	7	17. $\pm$ 1.
3 N	37°38'	8	35. $\pm$ 3.	8	37. $\pm$ 5.	7	11. $\pm$ 1.
4 N	37°30'	7	11. $\pm$ 1.	7	24. $\pm$ 1.	7	4.7 $\pm$ 0.2
5 N	37°13'	8	7.0 $\pm$ 1.2	3	43. $\pm$ 10.	8	2.9 $\pm$ 0.6
6 N	37°00'	8	26. $\pm$ 3.	8	70. $\pm$ 5.	8	16. $\pm$ 2.
7 N	36°50'	8	24. $\pm$ 2.	7	52. $\pm$ 7.	7	9.8 $\pm$ 1.1
8 N	35°42'	8	4.2 $\pm$ 0.5	8	60. $\pm$ 7.	7	3.8 $\pm$ 0.6
9 N	35°10'	8	14. $\pm$ 2.	8	100. $\pm$ 8.	8	11. $\pm$ 1.
10 N	34°28'	8	14. $\pm$ 1.	7	122. $\pm$ 8.	8	17. $\pm$ 3.
11 N	34°16'	7	36. $\pm$ 3.	7	84. $\pm$ 5.	7	14. $\pm$ 1.
12 N	34°02'	7	20. $\pm$ 2.	7	210. $\pm$ 12.	7	21. $\pm$ 3.
12 F	34°02'	7	23. $\pm$ 4.	8	460. $\pm$ 50.	8	30. $\pm$ 9.
13 N	33°53'	6	580. $\pm$ 90.	5	680. $\pm$ 100.	5	210. $\pm$ 40.
13 F	33°53'	8	340. $\pm$ 30.	8	1590. $\pm$ 60.	8	410. $\pm$ 30.
14 N	33°42'	7	150. $\pm$ 20.	7	4900. $\pm$ 480.	6	590. $\pm$ 80.
14 F	33°42'	8	78. $\pm$ 11.	8	6900. $\pm$ 900.	8	270. $\pm$ 60.
15 N	33°42'	8	88. $\pm$ 4.	7	2200. $\pm$ 200.	8	240. $\pm$ 20.
15 F	33°42'	7	48. $\pm$ 8.	7	4200. $\pm$ 400.	7	160. $\pm$ 40.
16 F	33°34'	7	45. $\pm$ 8.	7	470. $\pm$ 50.	7	56. $\pm$ 7.
17 F	33°22'	8	18. $\pm$ 4.	8	190. $\pm$ 20.	8	25. $\pm$ 6.
18 F	32°48'	7	13. $\pm$ 2.	8	71. $\pm$ 12.	8	9.1 $\pm$ 2.6
19 F	31°50'	6	26. $\pm$ 3.	6	68. $\pm$ 5.	6	12. $\pm$ 1.

and its degradation products has been demonstrated in the Pacific Coast ecosystem (19) Table 3-E. Notice that the concentration in vertebrates (ppm) is considerably greater than in invertebrates (ppb). East Coast estuaries are similarly affected; the Carmans River estuary and vicinity provide a broad overview of the problem (20) Table 4-E. These authors remind us that for many species, the subtle effects of long term exposure may be so acute that some of the species in the area have already been depleted to the point where study is difficult or impossible. A plea is made for examination of the entire ecosystem, particularly the carnivores or other top concentrating members rather than water levels in which quantities of pesticides are often vanishingly small or "non-detectable". Non-detectable to our chemical technology but not, obviously, to organisms living in the water.

Long term field studies by scientists from this area suggest that populations of many fish-eating birds have seriously declined over the past twenty years, even though the physical characteristics of the marsh area have remained essentially unchanged during this period.

Fishes and invertebrates from more northern waters do not show such high values as these examples (21). The additions from near inshore regions of pesticides are not as great, however, as more southern waters, and the one ex-

Table 3 -E

DDT AND RESIDUES IN PACIFIC COAST ECOSYSTEMS

Samples	Total DDT residues (parts per million)	Percentage of residue as		
		p,p'-DDT	DDE	DDD
<i>Mytilus californianus</i> (common mussel)*	19	28	28	28
<i>Thais emarginata</i> (short-spined purple snail)†	94	33	20	20
<i>Pisaster ochraceus</i> (common starfish), eight animals‡	20	15	24	32
<i>Micella polymera</i> (Pacific goose barnacle), forty animals‡	27	7	56	22
<i>Crassostrea gigas</i> (giant Pacific oyster), five animals§	29	42	24	17
<i>Strongylocentrotus purpuratus</i> (purple urchin)¶	5	100	0	0
<i>Patiria miniata</i> (sea bat starfish), ten animals¶	78	19	55	14
<i>Loligo opalescens</i> (squid), thirteen animals**	28	36	32	14
<i>Stichopus californicus</i> (sea cucumber), three animals††	93	43	25	25
<i>Pagettia producta</i> (kelp crab), six animals‡‡	42	16	62	10
<i>Thais emarginata</i> (short-spined purple snail), Monterey§§	103	28	45	15
<i>Mytilus californianus</i> (common mussel), Monterey	84	32	33	18
<i>Mytilus californianus</i> Ensenada, Baja California**	34	21	53	0
<i>Mytilus californianus</i> , Farallon Islands***	34	0	84	0

* Point San Pedro, San Mateo Co., May 26, 1963, pooled sample of twenty animals, shells removed before analysis; † Point San Pedro, San Mateo Co., May 26, 1966, pooled sample of eighty animals, shells removed before analysis; ‡ Point San Pedro, May 26, 1966; § Tomales Bay, Marin Co., September 15, 1965; || Point Arena, Mendocino Co., September 16, 1966, gonads of eight animals; ¶ Monterey, March 6, 1966; ** Monterey, June 16, 1965; †† Monterey, March 12, 1966; ‡‡ Monterey, March 6, 1966; §§ April 11, 1966, pooled sample of thirty-six animals, shells removed; || Monterey, April 11, 1966, pooled sample of 108 animals; ** July 17, 1965, pooled sample of fifteen animals; *** April 6, 1966, pooled sample of eleven animals.

Sample	Total DDT residues (p.p.m.)	Percentage of residue as		
		p,p'-DDT	DDE	DDD
<i>Ptychoramphus aleuticus</i> (Cassin's auklet), nine adults*	5.1	0.4	95	1.1
<i>Ptychoramphus aleuticus</i> , one adult found dead*	15.4	0.1	96	1.0
<i>Ptychoramphus aleuticus</i> , two adults†	1.0	3.8	87	4.0
<i>Ptychoramphus aleuticus</i> , three adults*				
Breast muscle	2.0	11	81	1.0
Brain	0.7	32	54	5.9
Liver	1.0	9.7	79	3.9
Subcutaneous fat	56	1.5	92	1.5
<i>Ptychoramphus aleuticus</i> , fourteen eggs*	10.8	0.3	96	1.0
<i>Larus occidentalis</i> (Western gull), two adults*				
Breast muscle	9.2	0.1	89	0.9
Brain	1.8	2.2	83	4.4
Subcutaneous fat	211	0.4	94	3.1
<i>Larus occidentalis</i> , nine eggs, one-egg clutches*	6.5	2.9	82	7.3
<i>Phalacrocorax pelagicus</i> (pelagic cormorant), one adult‡				
Breast muscle	0.8	1.3	83	11.9
Liver	0.7	0.0	84	10.9
<i>Phalacrocorax penicillatus</i> (Brandt's cormorant), five adults§				
Breast muscle	4.4	0.0	91	6.2
Liver	3.3	0.0	85	0.2
Brain (three birds)	1.2	0.0	92	5.2
<i>Pelecanus occidentalis</i> (brown pelican)††				
Breast muscle	84.4	1.4	91	4.8
<i>Uria aalge</i> (common murre)†	7.3	0.3	93	4.0

* Farallon Islands, April and May 1966; † Monterey Bay, November and December 1966. Although these species breed in California, the individual birds may have come from elsewhere; ‡ Tomales Bay, Marin Co., March 4, 1966; § Tomales Bay, December 31, 1965.

Concentrations are expressed in parts per million, wet weight. Unless otherwise indicated the whole bird was analyzed. Concentrations in eggs are based on the entire contents of the egg. The proportions of DDT (p,p'-DDT), DDE (p,p'-DDE) and DDD (p,p'-DDD) are expressed as a percentage of the total. o,p'-DDT and p,p'-DDMU constitute the balance.

Table 4-E

DDT RESIDUES IN CARMANS RIVER ESTUARY

DDT residues (DDT+DDE+DDD) (1) in samples from Carmans River estuary and vicinity, Long Island, N.Y., in parts per million wet weight of the whole organism, with the proportions of DDT, DDE, and DDD expressed as a percentage of the total. Letters in parentheses designate replicate samples.

Sample	DDT resi- dues (ppm)	Percent of residue as		
		DDT	DDE	DDD
Water*	0.00005			
Plankton, mostly zooplankton	.040	25	75	Trace
<i>Cladophora gracilis</i>	.083	56	28	16
Shrimp†	.16	16	58	26
<i>Opsanus tau</i> , oyster toadfish (immature)†	.17	None	100	Trace
<i>Menidia menidia</i> , Atlantic silverside†	.23	17	48	35
Crickets†	.23	62	19	19
<i>Nassarius obsoletus</i> , mud snail†	.26	18	39	43
<i>Gasterosteus aculeatus</i> , threespine stickleback†	.26	24	51	25
<i>Anguilla rostrata</i> , American eel (immature)†	.28	29	43	28
Flying insects, mostly Diptera†	.30	16	44	40
<i>Spartina patens</i> , shoots	.33	58	26	16
<i>Mercenaria mercenaria</i> , hard clam†	.42	71	17	12
<i>Cyprinodon variegatus</i> , sheepshead minnow†	.94	12	20	68
<i>Anas rubripes</i> , black duck	1.07	43	46	11
<i>Fundulus heteroclitus</i> , mummichog†	1.24	58	18	24
<i>Paralichthys dentatus</i> , summer flounder†	1.28	28	44	28
<i>Esox niger</i> , chain pickerel	1.33	34	26	40
<i>Larus argentatus</i> , herring gull, brain (d)	1.48	24	61	15
<i>Strongylura marina</i> , Atlantic needlefish	2.07	21	28	51
<i>Spartina patens</i> , roots	2.80	31	57	12
<i>Sterna hirundo</i> , common tern (a)	3.15	17	67	16
<i>Sterna hirundo</i> , common tern (b)	3.42	21	58	21
<i>Butorides virescens</i> , green heron (a) (immature, found dead)	3.51	20	57	23
<i>Larus argentatus</i> , herring gull (immature) (a)	3.52	18	73	9
<i>Butorides virescens</i> , green heron (b)	3.57	8	70	22
<i>Larus argentatus</i> , herring gull, brain§ (e)	4.56	22	67	11
<i>Sterna albifrons</i> , least tern (a)	4.75	14	71	15
<i>Sterna hirundo</i> , common tern (c)	5.17	17	55	28
<i>Larus argentatus</i> , herring gull (immature) (b)	5.43	18	71	11
<i>Larus argentatus</i> , herring gull (immature) (c)	5.53	25	62	13
<i>Sterna albifrons</i> , least tern (b)	6.40	17	68	15
<i>Sterna hirundo</i> , common tern (five abandoned eggs)	7.13	23	50	27
<i>Larus argentatus</i> , herring gull (d)	7.53	19	70	11
<i>Larus argentatus</i> , herring gull§ (e)	9.60	22	71	7
<i>Pandion haliaetus</i> , osprey (one abandoned egg)	13.8	15	64	21
<i>Larus argentatus</i> , herring gull (f)	18.5	30	56	14
<i>Mergus serrator</i> , red-breasted merganser (1964)†	22.8	28	65	7
<i>Phalacrocorax auritus</i> , double-crested cormorant (immature)	26.4	12	75	13
<i>Larus delawarensis</i> , ring-billed gull (immature)	75.5	15	71	14

tremely high value (for the list) is from the mackerel (54 ppm), a normally migratory, warmer water fish, which probably accumulated its higher residues while at the south central and southern coast of the United States. Table 5 - E.

One unfortunate consequence of studies such as these is this: Data collected in 1967-68 was not published until 1971. Once a rather comprehensive study is finished, other workers are reluctant to enter the area for a number of years. Thus, even though individual species may be examined, the impact on the total environment may not be resurveyed for some time. Our monitoring program should probably include some of the more sensitive species from coastal and estuarine environments, as well as periodic status reports, utilizing all available information, on the total health of the ecosystem.

Table 5- E

DDT RESIDUES IN ATLANTIC MARINE FISHES
AND INVERTEBRATES. CANADIAN LOCATION

DDT residues measured in Atlantic marine fishes and shellfishes collected in October 1967. Averages of four or five samples from different individuals are given, followed by the range in parentheses. All values have been rounded to two decimal places. A dash (-) indicates less than 0.01 ppm. Average size of individuals is given in centimeters, with carapace length for lobsters.

Species	Location*	Size (cm)	Organ	ppm			
				DDT	DDD	DDE	ΣDDT
Mussel, edible <i>Mytilus edulis</i> L.	M	7.6	Whole	-	-	0.05 (0.03,0.11)	0.05 (0.03,0.11)
Mussel, edible	E	6.7	Whole	0.01 (-,0.05)	-	0.06 (-,0.13)	0.08 (-,0.17)
Mussel, edible	St.A	4.4	Whole	0.04 (-,0.10)	-	0.05 (0.03,0.10)	0.09 (0.06,0.15)
Scallop, giant <i>Placopecten magellanicus</i> (Gmelin)	R	8.0	Whole	0.01 (-,0.07)	-	0.02 (0.01,0.04)	0.03 (0.01,0.09)
Scallop, giant	St.A	10.7	Whole	-	-	0.03 (0.01,0.03)	0.03 (0.01,0.03)
Clam, soft-shelled <i>Mya arenaria</i> L.	M	6.3	Whole	-	-	0.01 (-,0.04)	0.01 (-,0.04)
Clam, soft-shelled	E	6.7	Whole	-	-	0.05 (-,0.14)	0.05 (-,0.14)
Clam, soft-shelled	St.A	5.5	Whole	-	-	-	-
Oysters, eastern <i>Crassostrea virginica</i> Gmelin	M	7.8	Whole	-	-	0.01 (-,0.03)	0.01 (-,0.03)
Oysters, eastern	E	13.9	Whole	-	-	0.02 (0.01,0.02)	0.02 (0.01,0.02)
Quahogs, <i>Venus mercenaria</i> L.	M	6.1	Whole	0.04 (-,0.21)	-	0.01 (0.01,0.02)	0.05 (0.01,0.23)
Lobster, American <i>Homarus americanus</i> Milne-Edwards	R	8.5	Muscle	0.01 (-,0.02)	0.01 (-,0.02)	0.03 (0.02,0.04)	0.04 (0.02,0.08)
Lobster, American	R	8.5	Eggs	0.04 (-,0.09)	0.01 (-,0.04)	0.31 (0.07,0.94)	0.36 (0.07,0.94)
Mackerel, Atlantic <i>Scomber scombrus</i> L.	M	41.8	Whole	0.38 (0.28,0.48)	0.08 (0.04,0.13)	0.09 (0.05,0.16)	0.54 (0.45,0.77)
Salmon, Atlantic <i>Salmo salar</i> L.	M	59	Muscle	0.02 (-,0.04)	0.01 (-,0.03)	0.03 (0.02,0.04)	0.05 (0.02,0.10)
Salmon, Atlantic	M	59	Viscera	0.08 (0.04,0.19)	0.06 (-,0.19)	0.16 (0.08,0.27)	0.29 (0.15,0.65)
Cod, Atlantic <i>Gadus morhua</i> L.	R	58	Muscle	0.01 (-,0.04)	-	0.04 (0.02,0.05)	0.05 (0.02,0.08)
Cod, Atlantic	R	58	Viscera	0.40 (0.09,0.68)	0.10 (0.02,0.17)	0.24 (0.14,0.34)	0.75 (0.36,1.16)
Hake, white <i>Urophycis tenuis</i> (Mitchill)	R	64	Muscle	0.01 (-,0.03)	-	0.03 (0.01,0.05)	0.04 (0.01,0.08)
Hake, white	R	64	Viscera	0.19 (0.08,0.36)	0.10 (0.04,0.16)	0.13 (0.05,0.24)	0.43 (0.17,0.76)
Smelt, American <i>Osmerus mordax</i> (Mitchill)	M	16.5	Whole	-	0.01 (-,0.03)	0.01 (-,0.04)	0.03 (-,0.06)
Smelt, American	E	19.4	Whole	0.06 (-,0.16)	-	0.05 (0.02,0.09)	0.10 (0.02,0.19)
Flounder, winter <i>Pseudopleuronectes americanus</i> (Walbaum)	R	28	Muscle	-	-	0.01 (-,0.03)	0.01 (-,0.03)
Flounder, winter	R	28	Viscera	-	-	0.01 (-,0.02)	0.01 (-,0.02)
Tomcod, Atlantic <i>Microgadus tomcod</i> (Walbaum)	M	24.5	Whole	-	-	-	-

*M, Miramichi; E, Ellerslie; St.A., St. Andrews; R, Richibucto.

How Do Pesticides Enter Succeeding Trophic Levels?

Algae and other photosynthesizing plants as well as fungi and bacteria probably acquire pesticides by absorption across limiting membranes. The relative insolubility in water and the high solubility in lipids creating an apparently "active" accumulation. Whether active transport or passive diffusion is involved is still open to question. In any event, many algal forms are observed to concentrate pesticides to quantities far in excess of that of surrounding water. Data from the five state study area suggests concentrations over one thousand times water (11). Controlled laboratory studies have demonstrated concentrating abilities of 120-270 times the medium in seven days for 2 species of Blue-green algae, 1 Desmid, 1 filamentous species. (22), while studies with natural populations have demonstrated that benthic algal species can concentrate at least forty times the water concentration. (23). Observations in Scottish streams following the dumping of sheep dip have indicated that diatoms of the *Achnanthes* can concentrate dieldrin to over 1200 times that of water in less than one day. (24). Several species of aerobic floc forming bacteria were observed to absorb aldrin from solutions and concentrate 625 times the media in 20 minutes. (25)

Thus Protozoan species, especially those which feed on bacteria, can ingest considerable quantities of pesticide in very short periods. Diffusion through or across the general body surface as well as pinocytotic activity are other active routes of uptake.

Low concentrations of DDT (10 mg/70 ml) apparently do not inhibit growth of *Euglena* (26), but caution is emphasized here, since it was found that the suspending medium, ethanol, was responsible for growth anomalies observed. The suggestion is made the PCB in the medium was not taken up to any extent and that DDT was selectively absorbed, probably by some physiological control mechanism. With this organism, all of the initially added DDT was present after 5 days of growth and no degradation products were observed.

Chlorella and *Euglena* were observed to sorb and absorb 60 to 80 per cent of the quantity of lindane present in aqueous solutions (27). Concentration in the food chain at this level is specifically indicated but hydrolysis and microbiological degradation is not ruled out.

Much additional research at this fundamental level of uptake, accumulation and metabolism of aquatic food chains is badly needed.

Benthic forms, Zooplankton and Fishes

The primary route is probably through ingested food although entry through gills and, in general, the body surface, cannot be ignored. Most aquatic invertebrates respire by means of gills or some other thin membrane. Considering the rapid heart rate in most and high fat content of many it appears that rapid uptake and storage is possible by this route. Table 6-E taken totally from Johnson et al (28) is included since it is one of the few papers utilizing concentrations in ppb range. (The level found in many natural waters.) It can be seen that direct uptake occurred rapidly in the absence of food.

As-
tounding magnification occurred in only three days. The authors stress the impact of such magnification on succeeding trophic levels; (1) rapid accumulation during periods of limited pollution exposure (2) ability to concentrate even at extremely low ambient levels, (3) source of biological magnification of degradation products. Thus, the conversion of aldrin to dieldrin was 25% accomplished in three days and the degradation of DDT to DDE was 85% accomplished in the May fly nymph in three days. Additional metabolites were recovered from other organisms.

Table 6-E

BIOLOGICAL MAGNIFICATION OF ^{14}C -LABELED p,p'-DDT AND ALDRIN
BY FRESHWATER INVERTEBRATES

Pesticide	Organism	Stage of development	No./sample	Pesticide residue (mean value $\pm$ se ^a)				Biological magnification factor		
				Water (ng/liter)	Total body (ng/mg)			1 day	2 days	3 days
					1 day	2 days	3 days			
DDT	Cladocera									
	<i>Daphnia magna</i>	Mature adult	60	80.3 $\pm$ 13.7	2.04 $\pm$ 0.04	5.55 $\pm$ 0.31	9.17 $\pm$ 0.17	25400	69100	114100
	Amphipoda									
	<i>Gammarus fasciatus</i>	Mature adult	1	81.3 $\pm$ 13.0	0.38 $\pm$ 0.04	0.99 $\pm$ 0.15	1.68 $\pm$ 0.15	4600	12100	20600
	Decapoda									
	<i>Orconectes nais</i>	Mature adult	1	30.3 $\pm$ 13.7	0.071 ^b	0.171	0.233	880	2100	2900
	Palaemonetes									
	<i>kadiakensis</i>	Mature adult	1	100.0 $\pm$ 0.07	0.152 $\pm$ 0.01	0.375 $\pm$ 0.02	0.503 $\pm$ 0.06	1500	3700	5000
	Ephemeroptera									
	<i>Hexagenia bilineata</i>	Nymph	1	52.1 $\pm$ 10.0	0.49 $\pm$ 0.04	0.87 $\pm$ 0.02	1.68 $\pm$ 0.06	9400	16700	32600
	<i>Siphonurus</i> sp.	Nymph	10	47.0 $\pm$ 5.1	0.48 ^b	0.94	1.08	10200	20000	22900
	Odonata									
	<i>Ischnura verticalis</i>	Naiad	1	101.3 $\pm$ 5.8		0.375 $\pm$ 0.02			3500	
	<i>Libellula</i> sp.	Naiad	1	79.3 $\pm$ 4.3		0.072 $\pm$ 0.005			910	
Aldrin	Diptera									
	<i>Chironomus</i> sp.	Larvae	10	46.3 $\pm$ 3.5	0.36 $\pm$ 0.07	1.13 $\pm$ 0.20	2.2 $\pm$ 0.21	7800	24500	47800
	<i>Culex pipiens</i>	Larvae	10	104.6 $\pm$ 8.8		13.9 $\pm$ 0.78			133600	
	Cladocera									
Aldrin	<i>Daphnia magna</i>	Mature adult	60	16.7 $\pm$ 0.37	1.0 ^b	1.7	2.4	58000	100000	141000
	Ephemeroptera									
	<i>Hexagenia bilineata</i>	Nymph	1	21.3 $\pm$ 2.4	0.29 $\pm$ 0.04	0.44 $\pm$ 0.04	0.66 $\pm$ 0.08	13800	20900	31400
	Diptera									
	<i>Chironomus</i> sp.	Larvae	10	21.3 $\pm$ 2.4	0.26 $\pm$ 0.01	0.35 $\pm$ 0.04	0.48 $\pm$ 0.06	12300	16600	22800

^aData represent the mean value of at least triplicate samples.^bData represent the mean value of duplicate samples.

Several additional points are worthy of mention. Cladocera subjected to less than one-fourth the concentration of aldrin as DDT showed a two-fold biological magnification in one day for a rate of accumulation over eight times as fast as DDT. Similarly, Chironomus sp. and Hexagenia concentrated aldrin about four times faster than DDT in one day. The total biological magnification for Hexagenia bilineata was approximately equal for aldrin and DDT over the three-day period, but was only one-half the total magnification for aldrin in three days. This latter fact may reflect the suspicion that equilibrium storage capacity was being reached, or that once a compound has entered the body, a differential storage is possible. It should be noted that dipterous larvae and Cladocera are two of the primary foods of young fish in addition to being the two greatest concentrations observed.

A great deal of confusion seems to exist as to which is the correct or dominant route of pesticides into the bodies of fish. There would appear to be no reason to debate any of the data presented by various authors. Although techniques vary, all appear to be reasonably consistent with physiological principles. Thus the gill is suggested as the site of inward diffusion of pesticides (dieldrin) where it dissolves in the lipid portion of lipoprotein, in which

form it is transported to and incorporated into the lipids of various tissues (29). Concentrations of 169-515 ppb in bath water resulted in plasma perfusate concentrations of 64-220 ppb. This results in a constant inward diffusion gradient; continued transport and storage; thus, perpetuates the gradient.(30). Radioisotope techniques were utilized to show that brook trout accumulated almost ten times as much DDT from their food as from the water directly (31). Using comparative figures, pptr in water and ppm in food, they suggest that at their calculated rates, it would take the fish 12 years to accumulate 1 ppm total residues when exposed to a constant 3 pptr in water. Since yearling salmonids from lakes often contain 1-2 ppm in their first year of life, it is offered that the food chain is the major source of DDT concentration in fish.

Primary Production: Any energy-yielding or energy-requiring system must leave the source of that energy identified. Photosynthesis and carbon fixation are fundamental to the support of succeeding trophic levels. An understanding of the effects of pesticides on this basic biochemical and life support system is therefore essential. Natural bodies of water are quite diverse, as are the forms of vegetative life they support. Oceanic water masses and impounded or semi-impounded waters accomplish carbon fixation, primarily through the action of free floating phytoplankton green plants which, by definition, have very poor or no means of self-mobility. Rivers and other flowing waters, because of the movement of the water mass, support relatively few freely floating plant forms. Forms attached to the substrata, diatoms, coccoid and filamentous algae, accomplish a part of the photosynthetic task in these waters.

More recently it has been shown that often as much as 75% of the total energy-yielding food base in streams does not arise in the stream itself, but comes from the watershed in the form of bits of fragmented plant material. This allochthanous material could bring to the stream accumulated quantities of pesticide materials, along with loads of silt and running water, each contributing its share.

Each of these sources, including that portion of

airborne pesticides brought in by rainfall directly (previously co-distilled from the global environment) assure that pesticide compounds find their way into the water environment. Now, do these compounds actually exert a harmful effect on the total global photosynthetic picture, or, depending upon local conditions, a sufficient effect on photosynthesis in general to merit our concern?

DDT, when applied to laboratory cultures of coastal and oceanic phytoplankton species was sufficient to reduce photosynthesis in all at concentrations less than 10 ppb (32). It is emphasized that although such a level is high for the open ocean, it would be of the same order of magnitude as other authors have found for natural waters under certain circumstances (133 ppb in Florida salt marsh for 1 week following DDT spraying; 22 ppb in some California coastal waters; and 14-20 ppb added directly to Clear Lake, California). Levels far in excess of 10 ppb have been recorded at outfall sources in freshwater streams and lakes. The ecological importance of such physiological stress as is imposed by DDT is that species composition may be altered, allowing species which may normally be suppressed by others to "explode" and dominate the community for varying periods of time. thus, the normal ecological

succession is disturbed and community structure upset. The influence of varying toxic susceptibility is indicated in other studies (33) which show that some forms from different oceanic environments show dramatically different responses to DDT, dieldrin and endrin in culture. One species was inhibited by all of these pesticides at concentrations above 1 ppb with cell division markedly reduced at 0.1 pph, while another species was completely insensitive to these ranges. This extreme difference serves to further emphasize the dramatic influence on succession and dominance of algal populations referred to above.

Very few studies have been conducted on algal species native to the five-state study area. Work already referred to on natural communities of periphyton (11) is valid for an assessment of total accumulation of pesticides. It does not, however, identify the response of native periphyton communities to these pesticides. One such study which does utilize an ubiquitous, naturally occurring fresh water algal species indicates that DDT, dieldrin and toxaphene all decreased cell numbers at all levels of treatment in culture. In addition, total biomass and the rate of carbon assimilation were reduced. (33 a).

Static bioassays with three species of stoneflies (34) indicated that endrin and dieldrin were the most toxic organo-chlorides used out of thirty-eight different commonly used pesticide compounds. Differences between species is indicated as well as differences between sizes of the same species; the smaller (younger) individuals being more susceptible than larger (older). Carbonates and organo-phosphates were generally less toxic to stonefly naiads. It might also be mentioned that the symptoms of intoxication, increasing irritability, loss of equilibrium, tremors, convulsions, are precisely those features which would tend to expose these organisms to capture, ingestion and incorporation into the food chain. (Table 7E)

DDT and DDD were the most toxic compounds to cladocerans. (Table 8E) (35) .

Differences in toxicity between species is observed as well as differences between potency of certain insecticides.

Mention has already been made to the fantastic biomagnification possible in certain members of the food chain, (Table 6E) .

Good, comprehensive studies of a wide variety of aquatic insect larvae under similar laboratory conditions or identical natural conditions are lacking. We do find isolated examples which are useful.

Table 7-E

Estimated LC_{50} values of various insecticides (technical grade)
for naiads of three species of stoneflies, tested at 15.5C

Insecticides	<i>Pteronarcys californica</i> LC_{50} , $\mu\text{g/liter}$		
	24 hr	48 hr	96 hr
Endrin	4.0 (3.0-4.9)	0.98 (0.53-1.7)	0.25 (0.20-0.31)
Dieldrin	6.0 (4.0-9.0)	1.3 (0.76-2.2)	0.5 (0.35-0.71)
Heptachlor	8.0 (2.3-15)	5.6 (2.9-11)	1.1 (0.85-1.4)
Toxaphene	18 (12-27)	7.0 (5.0-9.8)	2.3 (1.3-4.0)
Parathion	28 (19-42)	11 (8.0-15)	5.4 (4.7-6.2)
Carbaryl	30 (22-40)	13 (10-16)	4.8 (3.0-7.7)
Malathion	35 (23-43)	20 (15-27)	10 (7.0-13)
DDT	41 (27-62)	19 (14-27)	7.0 (4.9-9.9)
Dursban	50 (38-65)	18 (12-26)	10 (7.0-13)
Trichlorofon	320 (200-512)	180 (125-252)	35 (22-55)

* Figures in parentheses are confidence limits of the LC_{50} for $p = 0$

	<i>Pteronarcella badia</i> LC_{50} , $\mu\text{g/liter}$		
	24 hr	48 hr	96 hr
2.8 (2.3-3.4)	1.7 (1.2-3.4)	0.54 (0.40-0.72)	
3.0 (2.2-4.2)	1.5 (1.3-2.0)	0.5 (0.37-0.67)	
6.0 (4.5-8.0)	4.0 (3.3-4.8)	0.9 (0.60-1.3)	
9.2 (6.8-12)	5.6 (4.0-7.8)	3.0 (2.0-4.4)	
8.0 (6.2-10)	5.6 (4.0-7.8)	4.2 (3.4-5.2)	
5.0 (3.6-7.0)	3.6 (2.9-4.8)	1.7 (1.4-2.4)	
10 (6.7-15)	6.0 (4.1-8.7)	1.1 (0.78-1.5)	
12 (8.8-16)	9.0 (7.0-11)	1.9 (1.3-2.7)	
4.2 (3.0-6.0)	1.8 (1.2-2.6)	0.36 (0.30-0.49)	
50 (39-64)	22 (16-29)	11 (8-16)	

.05.

	<i>Classenia sabulosa</i> LC_{50} , $\mu\text{g/liter}$ *		
	24 hr	48 hr	96 hr
3.2 (2.2-4.6)	0.84 (0.64-1.1)	0.76 (0.62-0.93)	
4.5 (3.1-6.5)	2.3 (1.8-2.9)	0.58 (0.40-0.84)	
9.0 (6.2-13)	6.4 (4.9-8.4)	2.8 (2.1-3.7)	
6.0 (4.6-7.9)	3.2 (2.2-4.6)	1.3 (1.0-1.6)	
8.6 (6.5-12)	3.5 (2.3-5.2)	1.5 (1.0-2.2)	
12 (9-16)	0.8 (5.1-8.0)	5.6 (3.9-8.1)	
13 (9.6-17)	6.0 (4.1-8.7)	2.8 (1.8-4.3)	
16 (12-20)	6.4 (4.9-8.3)	3.5 (2.9-4.2)	
8.2 (4.9-14)	1.8 (1.2-2.2)	0.57 (0.39-0.83)	
110 (76-159)	70 (52-94)	22 (16-29)	

Rather sophisticated measurements of respiration and glucose metabolism in stoneflies showed that exposure to DDT at 380 ppb was sufficient to elicit a change in oxygen consumption (raised) and alter glucose metabolism so that in treated organisms, 69 per cent of the glucose was catabolized via the pentose shunt as opposed to 83 per cent catabolized by this pathway in controls. Such subtle alterations of metabolic paths in food chain organisms could have far reaching consequences on total energy budgets for the ecosystem. Very few studies of this kind have been conducted and many more obviously are required. (36)

Table 8-E

COMPARATIVE TOXICITIES OF INSECTICIDES REPORTED
IN THE LITERATURE AND BY THE FISH-PESTICIDE
RESEARCH LABORATORY FOR FOUR SPECIES OF DAPHNIDS.
EC₅₀ IMMOBILIZATION VALUES ARE IN MICROGRAMS/LITER.

Toxicant	<i>Daphnia magna</i> ¹ 50-hour EC ₅₀	<i>Daphnia magna</i> ² 24-hour EC ₅₀	<i>Daphnia pulex</i> ³ 48-hour EC ₅₀	<i>Daphnia carinata</i> ⁴ 64-hour EC ₅₀	<i>Simocephalus serrulatus</i> ⁵ 48-hour EC ₅₀	
	63 F	63 F	60 F	78 F	60 F	70 F
DDT	1.4	4.4	0.36	2.2 ⁵	2.5	2.8
Methoxychlor	3.6	3.7	0.78	—	5.0	5.6
TDE (DDD)	—	4.6	3.2	—	4.5	5.2
Aldrin	29.2	30.0	28.0	4.0 ⁵	23.0	32.0
Heptachlor	57.7	52.0	42.0	20.0	47.0	80.0
Dieldrin	330.0	740.0	230.0	250.0 ⁵	240.0	190.0
Endrin	352.0	900.0	20.0	50.0	26.0	45.0
Lindane	—	1,100.0	460.0	—	520.0	880.0

¹ Values reported by Boyd (unpublished).

² Values reported by Kawai (unpublished).

³ Values determined in this study.

⁴ Values reported by Matida and Kawasaki (1958).

⁵ Values indicate 32-hour figures.

Fishes

A large number of publications have presented data on acute and chronic toxicity to fish and other aquatic organisms, of a wide variety of pesticide compounds. Unfortunately, very few of these have utilized aldrin or dieldrin of the insecticides or atrazine of the herbicides. The body of published information on DDT alone would fill volumes. Due to the paucity of information on aldrin, we have decided to review selected papers dealing with DDT where they demonstrate a particularly valuable point and other cyclodienes, as their mode of action might be expected to reflect the action of aldrin/dieldrin. It has been suggested by several authors recently that considerably more effort could and should be directed at studies utilizing organo-phosphates and carbonates since it is hoped by many that these less persistent compounds will eventually replace the more persistent organo-chlorides.

In a study of relative pesticide susceptibility to some common fishes, Macek and McAllister (37) found considerable differences not only between classes of pesticide compounds but between the various families of fishes. It was possible to establish a range of species susceptibility -- a hierarchy of response. It was not

possible to relate chemical structure absolutely with the observed response but it was suggested that such hierarchial rankings could be used to predict responses to fish populations. The idea is not new (V. E. Shelford arrived at similar conclusions in 1917 when investigating phenolic wastes). The point is that such an evaluation does appear to have merit, but is rarely applied by workers. It was pointed out, and should be emphasized, that safe levels based on assays with one group might be extremely hazardous for another.

Analysis of inherent biological variability as reflected in variability in genetic constitution and physiological condition of the test species is identified as being responsible for the wide differences observed to the same toxicant (38). (Table 9-E)

Table 9-E

The mean TL_{50} and coefficient of variability of p,p'-DDT for fish and aquatic invertebrates. The 96-hour values are given for fish and the 48-hour values are given for invertebrates

Species	Number of tests	Temperature (C)	TL_{50} (μ g/l) 24 hours	48 or 96 hours
Rainbow trout <i>Salmo gairdneri</i>	15	12.5	9.6 (27) ¹	7.2 (30) ¹
Fathead minnow <i>Pimephales promelas</i>	14	18.5	24.6 (47)	19.9 (39)
Channel catfish <i>Ictalurus punctatus</i>	10	18.5	25.8 (34)	17.4 (17)
Bluegill <i>Lepomis macrochirus</i>	18	18.5	14.7 (35)	9.5 (37)
Largemouth bass <i>Micropterus salmoides</i>	13	18.5	3.9 (28)	1.8 (28)
Daphnia <i>Daphnia magna</i>	11	21.1	-	4.0 (15)
Seed shrimp <i>Cypridopsis vidua</i>	10	21.1	-	54.0 (15)
Sowbug <i>Asellus breviceaudus</i>	9	15.5	7.8 (19)	4.7 (15)
Glass shrimp <i>Palaemonetes kadiakensis</i>	11	15.5	6.9 (20)	4.2 (17)
Damselfly <i>Ischnura verticalis</i>	9	15.5	60.0 (22)	22.5 (35)
Scud <i>Gammarus fasciatus</i>	17	15.5	10.4 (31)	3.6 (30)

¹ Coefficient of variability.

The importance of this feature of testing as it relates to the significance of acute exposures can hardly be overemphasized. The fathead minnow showed the greatest variation in susceptibility. It is unfortunate that data for the goldfish is not included since this species is routinely used in such studies and for registration applications.

Various metabolic effects have been noted in fishes. Thus, treating immature rainbow trout with 1.0 mg dieldrin/kg. BW (140 days) and subjecting to forced swimming for 24 hours. Total serum amino acids in control and DDT treated fish were decreased. Significantly, dieldrin exposed fish did not decrease. It was concluded that amino acids were preferentially utilized by dieldrin treated fish while fat and carbohydrate was preferentially used by DDT and control groups for an energy source during the first week of forced swimming.

RBT subjected to loading with DDT and dieldrin and then forced to swim showed that stressed dieldrin treated fish lost 32 per cent more weight during two weeks of stress than similarly treated controls or DDT loaded fish. The loss of weight of these two latter groups was 60 per cent more than fasted groups of fish, however.

Measurements of losses of mesenteric fats during the forced swimming showed that DDT was not appreciably metabolized until the depot fat was about depleted, then rapid mobilization and brain and liver inflammation, followed by death. Little fat was mobilized by stressed dieldrin treated fish during forced swimming (previously described) (39) and elimination followed predicted elimination half-life. Thus, a basic difference in the metabolic response of fish is noted between these two compounds. Rodgers and Stalling (40).

The importance of diet control in toxicological studies was pointed out by Mayer (41) in studies which showed that DDT and dieldrin acted synergistically when fed in combination to rainbow trout. More DDT was stored in the brain of fishes on low methionine diet than in those on high methionine diet.

A similar feature has been noted in rats and dogs and may be a general vertebrate response to combinations of these two chemicals.

Macek et al (29) present interesting data to indicate that dieldrin and DDT both increase lipogenesis in the rainbow trout (RBT). Furthermore, the effect of both of these organo-chlorides was additive and most significantly, it took several months of exposure to

cause this effect. Feeding combinations of DDT and dieldrin resulted in the trout retaining relatively more of the total load of DDT than of dieldrin. Thus, 98 per cent of the DDT was retained after 56 days and 50 per cent of the dieldrin was eliminated in less than 14 days. It is suggested that the fish have a greater capacity to metabolize and/or excrete dieldrin than DDT.

Data on responses of fishes to atrazine are absent. Simazine, a substituted triazine, has been utilized and, as most other herbicides, found to be far less toxic than insecticide compounds.

Concentrations of simazine g 0.1, 0.3, 1.0 and 3.0 mg/e (ppm) resulted in residues of 0.0, 0.1, 0.3, and 0.5 $\mu\text{g/gm}$ (ppm) in bluegill reared in these treated ponds. Dead and decaying vegetation lend an immediate and temporary enriching effect but this was ultimately offset by a decrease in net primary production. Although it was not commented upon, gross shifts in CO_3/HCO_3 ratios resulting from the treatment could have dramatic effects on feeding and food utilization by the fish. (43)

Features of the environment which alter respiratory rates such as the above might augment the harmful effects of pesticides.

We are cautioned that experiments with one year (age or size) class might yield spurious results when metabolism (respiration) rates are compared to uptake of pesticides. The slope of log oxygen-log weight relationship is considerably less than one in most species tested. Thus, because of their higher respiratory rate and hence higher respiratory volumes, smaller fishes accumulated greater concentration of compounds like pesticides for their weight. Since respiration generally follows the Q_{10} rule, fishes from warmer waters may be expected to accumulate higher levels of residues from water than fish from colder waters assuming equal ambient concentrations (44).

Measurements of respiration in fishes exposed to pesticides are largely lacking. One such study yielded rather variable results and fluctuations in respiratory rate in goldfish chemically subjected to sub-lethal concentrations of dieldrin (45).

Although variations in respiratory rate may provide rather sensitive parameters, it is felt that metabolic studies incorporating labelled compounds are far better indicators of meaningful metabolic events.

Once Inside the Body of an Aquatic Organism, How are Pesticides Degraded or Metabolized?

The liver is the site of active metabolic alteration of a great variety of chemical compounds.

Atlantic salmon degraded DDT to DDE and TDE within nine hours when immersed in solutions of the parent compound (46).

Decrease in the total quantity of organo-chlorine in ovarian tissue of the winter flounder was observed as the spawning season progressed. The total of DDT, DDE, heptachlor, heptachlor epoxide and dieldrin was sequential concentrated from October 30 (0.21 ppm) to March 29 (1.29 ppm). Although less than one-half of that value was reported by Burdick (47) to cause fry death, these authors felt that the high larvae mortality observed in this species at final yolk sac absorption time could be the result of synergistic response or species tolerance differences (47a).

The effects of intestinal microflora have been demonstrated to degrade certain pesticides (46). This general phenomenon, although minor, is nevertheless a known route to decay. DDT has a strong inhibitory effect on adenosine triphosphatase (Na^+ , K^+ , Mg^{2+}) at 5 ppm.

Noneverted intestinal sac of seawater-adapted eels showed impairment of fluid absorption when bathed in DDT solutions. This impairment was seen to have an enzymatic basis. The DDT at 5 ppm producing a 43 per cent inhibition of adenosine triphosphatase (Na^+ , K^+ , Mg^{2+}) activity in mucosal homogenates (48).

Osmoregulatory impairment in teleosts is thought to be involved with sodium transport and an ATP mixed system. Organo-chlorines have shown such inhibition when investigated. Lindane, endrin, chlordane and DDT inhibition of one or more ATP-ases from gill, muscle, brain, intestinal mucosae, and liver have been shown for a variety of freshwater and marine fish (49,49a).

In addition to inhibition of ATP-ase systems, organo-chloride insecticides has been observed to alter other enzymatic systems. Thus, dieldrin was lethal to the sailfin mollie within 72 hours at concentrations of 12 ppb and caused a significant increase in serum glutamic oxalacetic transaminase levels (50).

The liver, in addition to or as a result of, its being the site of most active in vivo degradation of pesticides, is also the site of greatest enzyme induction. As previously stated, the effect of enhanced microsomal induction of enzymes may be the most serious

single biochemical event. The effect on disturbed steroid metabolism and the consequences observed in raptorial and fisheating birds is well documented.

Young coho salmon were observed to succumb to DDT in diets in direct proportion to their size. Younger fish consumed a proportionately greater amount of food for their body weight and thereby received the highest dose (51). This feature is common to all young animals which are in an active phase of growth.

Dieldrin was demonstrated to reduce growth rate in 160 and 230 day experiments with guppies continually exposed to 1.0 and 2.5 ppb. While lower levels seemed to increase the intrinsic rate of increase, at higher levels (2.5 ppb) the intrinsic rate of increase was reduced by a combination of lower total reproduction, increase in number of aborted broods and delay in age of first reproduction. Post natal survival was not expected at concentrations up to 2.5 ppb (52).

Do Natural Populations of Fishes Contain Sufficient
Pesticide Levels to Validate the Prediction of
Potential Harm?

Spraying with DDT for flying insects around summer homes on Sebago Lake apparently resulted in abnormally high tissue levels of DDT and DDE in landlocked salmon (53). Tissue levels, especially gonads, showed a steady increase in fishes from three successive years, spraying by year class. Thus, age class III 1.2 ppm, age class IV 8.0 ppm and age class V, 8.8 ppm for tissues. Amount stored in gonadal tissue showed that females stored considerably more in this tissue than males. The differences as in most tissue examined in aquatic animals, was related to fat content. It should be noticed that species differences are particularly evident; five year lake whitefish and two year old brook trout showing the same DDT levels. The longer animals are exposed, the greater residues are accumulated, metabolism notwithstanding.

Do Different Fishes Accumulate and Store Different
Levels of Pesticides?

A survey of pesticide residue in Great Lakes fishes (53), Sebago Lake, Maine, fishes (54) (Tables 10-E and 11-E) suggest very strongly that varying amounts of pesticides

TABLE 10-E
DIELDRIN AND DDT RESIDUES IN WHOLE FISH

Species	(h)	Total Pesticide ppm	
		Dieldrin	Total DDT (DDE & DDD)
Smelt	4	.187	6.16
Suckers	40	.072	2.43
White Fish	18	.229	2.8
Minnows	1	.001	.57
Alewives	4	.121	2.05
Bullheads	2	.153	1.46
Carp	4	.315	2.83
Pike	5	.097	2.91
Chubs	4	.225	6.53
Yellow Perch	4	.054	1.59
RBT	18	.075	2.46
Brown Trout	8	.259	3.16
Brook Trout	8	.031	1.74
Lake Trout	5	.146	3.84
Coho	3	.209	10.3
Chinook	1	1.47	2.14

TABLE 11-E
AFFECT OF AGE ON DDT RESIDUES

Species	Number	Age Class	DDT ppm
Lake White Fish	11	V	6.2
Brook Trout	2	II	6.2
SMB	5	IV	2.0
	3	V	3.7
	4	VI	4.0
Chubs (live)	10	I	0.28
(dead)	6	I	1.0
Common Shinner			.60 (same site as Chubs)
			.32 (1 mile away)
Smelt	200		.70

are accumulated and stored. Differences between species may certainly reflect differences in feeding habits but does not preclude the fact that inherent differences in the basic physiology of the animal is involved. A general increase in tissue levels is indicated as fishes increase in age (see SMB and salmon). It should also be noted that no direct relationship appears to exist between the storage of dieldrin and/or DDT although all animals are theoretically exposed to the same concentrations. Although not documented by anyone, it would appear that such differences could accrue largely from the levels of residues in food chain organisms. Differences in retention rates is not ruled out.

Terata

Brood stock of the channel catfish proved to be already highly contaminated with organo-chlorine residues. Diets of 0.0, 0.3 and 2.0 $\mu\text{g/g}$ B.W. of endrin for one month prior to spawning produced a large incidence of deformity in fry of the following types:

Tail-less	44 $\pm$ 9%
Spinal curvature	8 $\pm$ 3%
Large mandible	9 $\pm$ 2%

It was impossible to correlate the terata with any one residue due to the prior contaminations of the breeders. That this result was due to the treatment and high residues is borne out by the fact that brood stock from the same source and maintained on pesticide-free regimes for 2 years, exhibited fewer than 3% deformed progeny. (55)

It is seen that fishes such as those catfish examined by Morris and co-workers (56) from Iowa and which carried a body burden of organo-chlorine pesticides (dieldrin = 500-1000 ppb) of the same order of magnitude or higher, are or were quite capable of suffering some degree of reproductive failure. These small fry are generally too small to be noticed; the potential for harm would only be seen in the strength or weakness of year classes years later (like 1975-1976+).

Lake trout fry sustained a heavy mortality at hatching when egg fat content reached 2.95 ppm or above (47). Fry of the Sebago salmon had 76 ppm DDT in fat, 24 PPM DDT one week after yolk sac absorption. On a wet weight basis, this was 0.76 ppm; no mortality was observed (53).

Gonad development was reduced and a lowered gonadosomatic index was evident in goldfish chronically

exposed to endrin, through feeding at levels .43 ppm and .143 ppm in food. These figures are not inconsistent with levels observed in natural food organisms (57).

Similar injury to sac fry of the cutthroat trout was noticed and reported as early as 1963 (58). More recently, studies have demonstrated this in brook trout eggs. The release of DDT by metabolized phospholipids is probably of greater importance than the utilization of triglyceride oil droplets as previously thought (59). These studies indicate that the greatest phospholipid mobilization occurred at 65-70 days, the period of final yolk sac absorption and greatest fry mortality.

Submersing carp eggs in various insecticides resulted in 50-100 per cent mortality above 5 ppm; none caused significant mortality below 1 ppm, leading the researchers to conclude that carp embryos are less susceptible to pesticides in the water than are adults. Whether or not uptake and accumulation reached levels known detrimental to trout and salmon was not determined. Chlordane was found to be responsible for slightly increased viability and apparently stimulated development time. Additional data is desperately needed to determine whether chemicals like chlordane can stimulate microsomal enzyme induction and thereby effect developmental rates in fishes (60).

Do aquatic organisms exhibit behavioral changes in response to certain pesticides?

The obvious results of acute toxicity are well documented. Subtle, difficult-to-identify changes in behavior associated with sublethal, chronic exposure to pesticides is not as well documented. The chlorinated hydrocarbons including the cyclodienes are known to effect both central and peripheral nervous tissues in mammals and birds. From the animals' point of view and for his continued success as a member of the larger population. Behavioral alterations which reduce alertness, increase restlessness, reduce visual acuity or otherwise are responsible for exposing the animal to capture or debilitating injury all have a damaging effect on the long term success of the species.

Brook trout, exposed to DDT at sub-lethal concentrations of 100-300 ppb increased the duration of response to a simple mechanical disturbance. The response is greatly potentiated by cold. The greatly increased instability in sensory nerve fiber firing in the cold suggests that DDT (and perhaps other compounds as well) may be more lethal in colder temperatures. A constant barrage of uncoordinating bursts may easily reduce the animal's vigilance.(61). Twenty parts per billion of DDT for 24 hours was sufficient to seriously reduce the ability of brook trout to respond to training.

It is also pointed out that such a disturbance may be devastating to the sensitivity of temperature selective mechanisms in cold water tissues.

In a subsequent paper (62), under different experimental conditions, it was determined that DDT did not appear to affect learning per se, but that the effect of sub-lethal concentrations under certain learning conditions significantly alter the ability to perform certain tasks. The possibility that sublethal amounts of DDT could alter a fish's natural repertoire of CR's produced in response to a given conditioning regime is suggested (62 A).

Have aquatic organisms developed resistance to pesticides?

The development of some degree of resistance to insecticides by vertebrates has been erroneously heralded as a significantly desirable feature by many. The claim that such resistance signals the development of an ability of "cope" with the compounds in question overlooks and tends to overshadow the biological and ecological significance of such data. The inescapable fact is that any such resistance implies a genetic change in the target species. Any compound capable of affecting one such change in the genome can conceivably be responsible for many more unidentified changes which might spell doom for the species.

Another undesirable feature of such resistance is that resistant species can develop massive body burdens of persistent compounds which, when incorporated into the food chain, could easily prove fatal to susceptible organisms higher in the food chain. Examples of such resistance are presented in Table 12.

It is interesting to note that in these and related studies the greater resistance is seen to aldrin, dieldrin, endrin and related pesticides, much lesser resistance is seen with DDT. It is suggested that a combination of heavy use of DDT, its stability, and the absence of DDT resistance to any extent emphasizes the danger of DDT (63).

TABLE 12-E
ALTERATIONS IN LC₅₀ IN NATURAL FISH POPULATION
DUE TO PESTICIDE RESISTANCE

Species	Previously Exposed 48 hr. LC ₅₀	No Prior Exposure 48 hr. LC ₅₀
Golden Shiner	900 ppb	25 ppb
Bluegill	900	25
Green Sunfish	1,250	33
Mosquito Fish	500	16
Black Bullhead	55	2.5

Utilizing mitochondrial preparations from both resistant and susceptible strains of the mosquito fish (64) it has been possible to identify enzyme alteration and suggest that vertebrate resistance is a membrane phenomenon involving either a physical alteration of the membrane, a functional modification, or both. Using a succinic dehydrogenase-mitochondrial membrane as the model it is indicated that the action of certain organo-chlorides may be a general action involving disruption of cellular function in all organs and tissues of an animal rather than a direct and unique central nervous system involvement.

We have very little data at present to indicate how stable the resistance patterns may be in natural populations.

We would like to mention a recent paper which, although not dealing with the aquatic ecosystem,per se, does make a very valuable point. Chromosomal changes in natural populations of the fruit fly Drosophila pseudobscura have been correlated to DDT applications and residue patterns in distribution area. One type of change was occurring progressively with time over a great area and could not be correlated to any particular meteorological event or activity in May other than DDT spray applications. Without laboring the point, what was found was an increase in percentage of one type of chromosome and a decrease in others. Specific landmark alterations are directly correlated with DDT applications and aerial drift into specific areas from these applications. (65) Increase in ST and PP chromosomes and decrease in AR and CH are quite pronounced (Table 13)(b). The important point is this. It required over 24 years of research effort with an animal which has many generations per year by teams of internationally renowned geneticists to identify this change in natural populations. It should not be surprising that we have difficulty identifying genetically based population changes in animals such as native fish which have generation times of three to eight years or more.

In any event the resistance to pesticides observed should be sufficient to warn us of biochemical changes

Table 13-E

ALTERATIONS IN CHROMOSOME FREQUENCY IN
FRUIT FLY, CALIFORNIA

Extracts from Tables in Publications by Dobzhansky on
Changes in Population Percentages of ST, AR, CH, and PP Chromosomes

Month and year	ST	AR	CH	
(a) April 1939	32.5	30.0	32.5	
May 1939	32.6	28.5	36.2	
June 1939	24.8	30.8	41.2	
July 1939	28.6	29.3	37.3	
Aug. 1939	29.5	30.5	37.6	
Sept. Oct. 1939	26.0	35.7	35.1	
April 1940	30.6	22.8	42.7	
May 1940	26.8	22.1	47.1	
June 1940	31.9	20.7	43.4	
July 1940	34.5	24.8	37.4	
Aug. 1940	37.6	26.4	31.5	
Sept. 1940	41.2	17.6	32.4	
May 1941	29.0	29.4	37.9	
June 1941	38.3	17.6	39.3	
July 1941	35.4	27.2	33.5	
Sept. 1941	38.2	25.0	32.4	
April 1942	45.1	17.6	29.4	
May 1942	45.1	14.7	33.3	
June 1942	28.2	15.4	46.4	
July 1942	26.0	18.0	52.0	
April 1945	41.0	22.2	29.2	
April 1946	52.0	15.5	23.7	
June 1946	48.0	15.0	32.5	
Year	ST	AR	CH	PP
(b) 1945	35.7	35.7	17.2	—
1946	30.9	36.6	17.1	0.3
1947	30.0	39.4	20.2	0.7
1950	20.3	49.8	17.4	2.8
1951	29.2	43.2	11.2	4.6
1954	27.3	36.4	12.6	11.7
1957	45.3	33.2	3.8	9.8
1959	39.9	35.6	10.7	4.4
1961	64.3	14.0	3.4	6.3
1962	53.6	27.1	2.2	8.7

(a) Populations at Keen Camp, western face of San Jacinto Mountains. PP chromosomes not yet present here (from ref. 17).
(b) Pooled yearly data on gene arrangements at Mather, 1945-1962 (from ref. 24).

which certainly could foretell if genetic changes occurring in natural populations. At present there appears to be no laboratory experiments which verify the alarming field data presented for resistant populations of fish stocks.

Many of the naturally occurring aquatic Dipterous larvae would be obvious choices to test for genetic changes. Unfortunately, we do not have the background data required to identify a suitable baseline value and this kind of experimentation appears to be largely untried.

Standards for Testing With Living Organisms

It appears to the contractor that one of the areas which is badly in need of remedial help is that of standards. What constitutes adequate standards for tests of acute or chronic toxicity, which organisms are truly adequate, which kinds of tests and measurements will be made, and, most important who will decide what these criteria shall be? Sadly the words of Cope (66) come back to sharpen our focus. "On the other hand, the reporting of toxicity data in a complete manner has lagged behind, and today's literature is little improved over yesterday's with regard to completeness and susceptibility to interpretation. He cites (and we take the liberty of adding to the list) three types of information required:

- (1) The fish themselves (or any other organism)
- (2) Methods used in experiment (or other valuable data from field measurements.
- (3) The environment

We have been unable to detect that strict adherence to these requirements is followed today, despite the restatement of such aims by numerous workers in the field. (67, 68 , 69 , 70 , 71). The problem seems far from solution since it appears that differences of opinion and

interpretation exist today in what constitutes "safe" levels of pesticides or any other pollutant see especially Sprague (71). The establishment of safe or "no-effect" levels seem remote indeed when we note that the FDA action guideline G 300 ppbDieldrin in fish flesh for human consumption is a quantity sufficient to cause considerable damage to other members of the aquatic ecosystem in chronic exposure tests. Such a number, empirically derived from experimental data has real value, however, and probably deserves serious consideration by all workers. The difficulty of arriving at suitable numbers is made doubly difficult by considering the multiplicity of environmental parameters involved.

It has been suggested (68) that where mounting evidence demonstrates that a pesticide is an undesirable or suspected contaminant of the aquatic environment its use would be halted until proven safe, particularly in those chemicals which accumulate in succeeding trophic levels or to which resistance has developed (See earlier).

Water itself Appears to Cause Considerable Trouble. What Water shall be Used?

The use of a standard test water for acute and chronic bioassays would appear to be an absolute minimal requirement

when investigating the responses of aquatic organism to pesticide compounds. Too often this has not been done, more often than not laboratory tap water or natural water is used (unspecified chemistry). The practice of specifying the basic water chemistry has been followed by the Fish Pesticide Laboratories and other responsible research institutions. It should likewise be included that temperature and photoperiod should always be included. It would seem desirable (although not always possible perhaps) to establish such as acute and chronic bioassays would be conducted so that various research efforts would be more strictly comparable.

It should also be noted that the drinking water supplied to laboratory mammals varies quite considerably around the country. It has been shown that variations in carbonate content can yield strikingly different results in kidney enzyme activities. Since alteration and protein metabolism and elimination of pesticide metabolites are problems these animals might face in acute or chronic studies this consideration, if implemented, should yield more consistent results. In any event the inclusion of a series of field conducted experiments utilizing natural water supplies would appear to be very

desirable as a complement and comparison to laboratory studies so long as the water quality is stated.

The entire problem is summed up very well by Walker (68) for herbicides:

We need to:

- (1) Better relate acute toxicity data to chronic effects or hazards posed by field use;
- (2) Define the significance of residues to the actual hazard posed;
- (3) Determine effects of multiple exposures and use patterns of several pesticides and how they will affect toxicity, efficacy and residues.
- (4) Recognize and evaluate complications of water quality, physical conditions, kinetics of absorption-desorption, and biological variables on toxicity, efficacy and residues
- (5) Develop adequate information on the mode of action, absorption, distribution, chemical metabolism, accumulation and excretion of each herbicide
- (6) Know the effects on the behavior and ecology of non-target organisms.
- (7) Develop methods of formulating and applying herbicides to minimize hazards to non-target organisms.
- (8) Find methods for speeding residue loss, degradation in water, soil, fauna, and flora and for the disposal of herbicide containers.

- (9) Establish guidelines to interpret this information and translate it into label recommendations and precautions in use patterns; and
- (10) Be more concerned with all uses of water and its depreciation in terms of future needs.

These comments would appear to be equally valid if we included insecticides (or other pesticides) as well. It can be seen that there are serious deficiencies in our knowledge of everyone of the aforementioned areas.

There would seem to be some hope for the future, however, the Chemicals in Fisheries Committee of the American Fish-ries Society is preparing a desk reference for all biologists, administrators, and students on the "Use of Chemicals and Methods for Evaluation in Fish Culture and Fisheries Management. Hopefully this long overdue effort will point the way to more critical evaluation and thoughtful experimentation in the field of pesticide research.

The fact that acute toxicity data can be misleading is clearly demonstrated by Post (72), Table 14-E.

TABLE 14-E
COMPARISON BETWEEN DIELDRIN AND DDT TL_M
FOR FOUR SPECIES OF SALMONIDS

Toxicant	Species	Fish Body Weight (g)	TL _M (p25)
Endrin	Brook Trout	1.15	0.355
	Brook Trout	2.04	0.59
	Cutthroat Trout	0.37	0.113
	Cutthroat Trout	1.30	0.192
	Rainbow Trout	1.24	0.405
	Coho Salmon	1.50	0.77
	Brook Trout	1.15*	7.4
	Brook Trout	2.13	11.9
DDT	Cutthroat Trout	0.33	0.85
	Cutthroat Trout	1.25	1.37
	Rainbow Trout	0.41	1.72
	Coho Salmon	0.50	11.3
	Coho Salmon	1.65	18.5

It is seen that considerable difference in 96 hour TL_M exist between the four species Cutthroat and Rainbow Trout are often common co-habitants of much of our western waters, yet they differ by a factor of three in their response to endrin. Differences between these species and the Brook Trout are even more pronounced for DDT. This serves to point up the questionable practice of specifying a certain fish (i.e., the bluegill) as the sole or preferred warm water fish for such studies. How pronounced the differences become in chronic sub-lethal exposures is unknown at present.

It must be clearly stated that no overt harm to humans has been demonstrated resulting from exposure to normal levels of DDT or cyclodienes. On the other hand, many deaths are recorded annually from organo-phosphate pesticide use, especially in areas of high exposure or frequent use. At least two obvious problems are involved here: (1) Do DDT and the cyclodienes cause identifiable harm to persons either occupationally exposed or by virtue of heavy residential use of the pesticides; and (2) Other than fatal or near-fatal exposures to organo-phosphates, can identifiable harm to persons be demonstrated by virtue of chronic or sublethal exposures to these pesticides?

Volumes of data are available from a variety of sources. It is not anticipated that the controversy over the carcinogenicity or mutagenic capabilities of these compounds will be resolved for some long time. Several features do emerge, though, and they seem to be common to the organochlorines as a group. Thus, the strong suggestion that at least some of the responses may be general tissue responses and as a result might be common to all vertebrates.

A considerable number of studies have dealt with long term occupational exposure or chronic ingestion of varying amounts of DDT in humans. These studies for the most part have failed to disclose significant tissue, physiological or biochemical (especially blood parameters)

alteration (73, 74, 75, 76 , 77, 78, 79 , 80, 81).

Persons occupationally exposed do, as might be expected, carry much heavier body burdens than the general public. Amounts of DDT and DDE in whole blood samples have been shown to be transient and related to the recency and the extent of the exposure (75).

It has been suggested by these workers that of the metabolites, DDE would provide the more adequate and meaningful measure of exposure for a prolonged time. This is borne out in later studies which demonstrated that the initial dechlorination of DDT is of critical important to its metabolic fate. Conversion to pp-DDD allows further degradation to pp-DDA, a water soluble and readily eliminated metabolite. Dehydrochlorination, on the other hand, results in the formation of the stable metabolite pp-DDE, which is avidly retained in adipose tissue (82). One of the results of such studies appears to be that the conversion of DDT to DDE is extremely limited in subjects who have either inhaled or ingested DDT. The rapid conversion to DDD is shown, however. It is suggested that tissue storage levels of pp-DDE in the generation population probably originate from pre-formed dietary pp-DDE rather than the in vitro degradation of pp-DDT. It is suggested that the loss of pp-DDE from adipose storage may take many years in man since loss from storage in man is much slower than for monkey, dog or cat.

Lindane, the γ isomer of benzene hexachloride, has been shown to be readily absorbed through skin, respiratory tract and gastro-intestinal tract; once absorbed it is rapidly eliminated in urine and feces unlike the β -isomer which does store in depot fat. Studies conducted on persons exposed from periods of weeks to years failed to disclose clinical symptomology or physical evidence of disease clearly attributable to this exposure.

Other workers have failed to detect pathological differences between control and exposed populations (80), although the suggestion is offered, that when considered in total the differences do indicate a physiological response to pesticide exposure. It is argued by many that present exposure levels in the county indicate a high degree of safety of DDT for the general population. Rates of ingestion 555 to 1250 times the general population rate failed to elicit demonstrations of clinical injury (83). It should be indicated at this point that most of the chronic exposure studies in question with humans have been performed on men. Prison inmates, male students, medical students, formulators, tank men, sprayers, etc. Thus, the criteria of effect or no effect may present a biased view. Evidence has been accumulating that age, race and sex do dramatically effect the prevalence of DDE in blood, and fatty tissue. Especially

important here are studies sufficiently sophisticated to consistently identify demographic differences of DDE (or any other metabolite) in blood which are due to person, place, and time, and which suggest subtle variations in DDT exposure within the general population (80). Results from Community Pesticide Studies in South Florida (81,84) and Iowa (85,86) and others (87) suggest that differences observed are due to factors associated with socioeconomic conditions (housing, sanitation). Thus, high levels of DDE in blood relate well to the economically disadvantaged (southern rural Negro, ghetto Negro) or close proximity to available sources (above and both northern and southern farmers). The more disadvantaged persons utilize the less expensive pesticides (containing DDT). (81). Although no significant morbidity excess was found in pesticide workers when compared to the general population, blood biochemistries did reveal subtle differences between exposed and the controls. It is of significance that rural Negro children had levels that approached those of heavily exposed industrial workers (87).

Farming habits as they related to high and low pesticide use was observed to produce significant correlations between certain chlorinated hydrocarbon exposure and blood biochemistries. No evidence of organic disease

was isolated from clinical examinations of high and low use groups (88). The subtlety of exposure and the variety of routes has been presented (89 , 90).

In addition to the demonstrated estrogenicity of in op-DDT in rats (91), DDT has been shown to cause significant changes in neonatal mineral metabolism (92), and DDE may be correlated to prematurity in populations of humans chronically exposed (93).

Transplacental passage of insecticides has been clearly demonstrated for other animal groups as well as humans.

Interesting studies with dogs have recently been presented. Reproductive failure was noted in all females receiving daily doses of DDT or Dieldrin for varying periods of time (94). Significantly, many of the dogs contained body burdens less than those observed in occupationally exposed humans. Results of these experiments also indicated a direct synergism between DDT and dieldrin as seen in trout, and suggests very strongly that this response (dieldrin slowing the retention of DDT and its metabolites) may be another general vertebrate tissue response.

Insufficient evidence is present at this time to suggest that DDT or other organo-chloride compounds, at the levels currently encountered, pose an immediate health hazard to humans of the general population.

Certain ethnic groups and the occupationally chronically exposed farmer or formulator may be carrying body burdens not consistent with the interests of best health.

Although it is not possible to show convincing direct clinical indications of harm to humans from organochloride compounds, this is not the case with organophosphate pesticides. The contractor does feel, however, that sufficient propensity for harm is indicated from studies on other vertebrates from the long term exposure to sub-lethal levels of organochlorides. A sufficient number of general tissue and organ responses have been indicated from studies with other vertebrates to suggest the likelihood of such responses in man with continued exposure to certain compounds. Even if man escapes the physiological damage observed in other vertebrates, the environment has not escaped, and will continue to suffer.

The next section deals specifically with the contractor's efforts to determine the propensity for harm to agricultural uses of pesticides presently, as well as that of the future. The results of agricultural use (reported as incidences) both to man and his environment are indicated.

Incidence of Injury

The contractor has elected to treat all incidents in this subsection because of the thread of continuity common to most, if not all, cases. This has been and continues to be the carelessness, ignorance, and, to a large measure, the truculent attitude widely held that one is trying to reduce a truly remarkable agricultural effort by unequivocally banning all pesticide use.

The purpose of this section is to indicate that a potential for harm does exist to livestock, to the environment, and to fish and wildlife resources as well as to man's own health and safety.

It should be realized that agencies which maintain and analyze statistics, and disseminate safety information do so solely to protect the public health. However methods of reporting, retrieval, recording and collection vary in effectiveness and efficiency. Also personnel in charge of these agencies are not always able or willing to disclose what facts they might have. Thus in the five state study area - an area of relatively intense use of pesticide products - one finds fragmented information on the extent of real or potential harm

Some bright spots do exist and these will be commented upon in the following text.

Farm Injury - Human

County agents and farmers were surveyed to determine the extent of possible harm to farmer/applicators from the use and application of pesticides. When county agents were questioned, twenty-five to thirty (25-30 percent) reported knowing or hearing of particular incidents of exposure within the past year. Others indicated no knowledge of incidents within their county. The agents were located throughout the state and can be considered representative of a state. Figures for agents responding are shown below:

	<u>Ill.</u>	<u>Iowa</u>	<u>Kan.</u>	<u>Minn.</u>	<u>Mo.</u>
Incidences of human injury	6/46	13/47 ¹	15/42	12/45	16/37

¹Positive responses/ number of farm agent contacts.

The greatest cause of illness was spray drifting back on the operator, with numerous examples of mechanical break down of the equipment, and contact resulting from that break down. Estimates of man hours lost from an incident varied from 4 hours (an afternoon) to as many as three weeks. The average cost time in the field per exposure was about three (3) days. Phorate and disulfoton fumes were most often singled out as

being responsible for operator complaint of illness.

According to the agents, in all cases, including mechanical failure, operator carelessness was blamed as primarily responsible for the injury. In many cases agents indicated they had cautioned farmers to use protective clothing, but the warning went unheeded. In the responses received, there seemed to be an overriding lack of sympathy for farmers who did not follow manufacturers or container directions, wear protective clothing, wash off after exposure, etc. For obvious reasons a clear case of misuse of a compound was severely criticized by the agents.

The nature of incidences is generally supported by farmer assessment of use problems. Container disposal and applicator safety are regarded as the least important problems facing a farm user.

Farm agents are aware of this problem, as shown in their responses:

- did not wear protective clothing
- carelessness
- did not follow directions
- precautions not followed
- operator did not follow recommendations
- guilty of improper storage and use
- improperly sprayed during high winds

faulty information

faulty storage

farmer did not follow advise

commercial firm may be licensed but the operator was careless

no protective clothing - no mask

farmers fail to realize these are hazardous chemicals

some of the farmers in my county have very poor reading skills

dealers are sometimes careless in sales

some of the applicators are irresponsible

County agents do feel pesticide use is essential to maintaining high crop yield. However a great number of them also appreciate the necessity for continued and improved educational programs. Many suggest the necessity of improved regulatory laws but, do not want to see these laws become overly restrictive.

Relative importance of reported pesticide "incidences" is an extremely sensitive area. The responsible agent and the farmer both feel the problem is distorted out of proportion to the magnitude of damage observed. Both are extremely defensive about use of pesticides, and alternatively call attention to the often careless or irresponsible utilization by urban dwellers. They see ". . . a few dead stunted bluegill" as the result of careless use - as potentially distorted

ammunition to be used by . . . the environmental extremist. The point is not without foundation.

With regard to development of a total picture of use and misuse, little comment is made about pesticide or residue which leaves the land and enters public waterways (methods of transport are detailed in "Route of Pesticides into the Water Environment").

Also, it should be pointed out that most accidental exposures are the result of improper application or obvious disregard of adequate safety measures. Containers and label directions, although superficially adequate, do not draw sufficient attention to the dangers. This situation, compounded by the applicators reluctance to utilize safety clothing, plastic gloves, respirators, etc. create a potentially hazardous medical situation.

Farmers in the five state area responded with similar figures of incidence. However, it was also implied that farmers do not report everything to the agents. Based on the data gathered, the two most common illnesses observed, their responses are shown in Table 15-E.

Major questions raised during the contractor's data gathering attempts included: (1) Are there injuries which are not being reported? (2) Are there simply no injuries resulting from pesticide use?

TABLE 15-E

RESPONSE OF FARMERS TO INCIDENTS OF INJURY
RESULTING FROM FARM USE OF PESTICIDES

	Illinois	Iowa	Kansas	Minnesota	Missouri
Total Replies	52	98	57	60	64
No. Use Pesticides	49	92	46	46	55
Total People Ill	14 (28.5%)	17 (20.3%)	11 (23.9%)	11 (23.9%)	11 (20%)
Do Not Use Pesticides	2				1
Break Down of Illness Reported					
Headaches	10	13	6	6	4
Dizziness	3	5	2	3	1
Sick to Stomach	5	8	7	6	5
Other	3	4	1	1	1
Left Question Blank But Use Pesticides	2	26	6	3	5

(3) Are there injuries to farmers which are reported to doctors but not to state or local health agencies? (4) What other kinds of damage to wildlife or livestock does occur and go unreported in the five state study area?

The contractor contacted state health officers or offices and/or state officers in charge of poison control centers, state pesticide officers, vector control authorities, state veterinarians, bureaus of

hazardous substances, and similar agencies in each of the five states to determine answers to the above questions.

Table 16E indicates response by the states to the contractor's pesticide poisoning reporting queries.

It is significant that none of the states has a standardized system for recording or noting of injury to farmers. In most cases accidental poisonings are recorded by poison control centers predominantly for children from age 0 to age 12. (This situation is detailed later in the chapter). Table 17E identifies state officials contacted.

Illinois

Dr. H. Petty indicated he was somewhat vexed by the lack of enforcement of the memorandum of understanding to which Illinois is a signatory. "We have the agreement but with no teeth in the law." He suggested one of the reasons for the lack of machinery for reporting pesticide-related illnesses might be due to legal responsibility and the confidential nature of patient/doctor relationships.

He further suggested there has been some purposeful confusion in terminology fostered by extremists, i.e., malathion (low toxicity) and parathion (high

Table 16-E

STATUS OF REPORTING OF HUMAN INJURY RESULTING FROM PESTICIDE USE BY STATES

Agency of System	State Health Department	Poison Control Center	Alert System	Other (Specify)	Anticipated
Illinois 1000	¹ No	Yes, feel have ² good cooperation	No	Memorandum of Understanding. See comments.	?
Iowa 2000	No	May be poor	No	Institute of Agricultural Medicine Survey. Memorandum of Understanding.	M.D. alert and request for cooperation.
Kansas 3000	No	Felt they do <u>good</u> job	Yes, Rodenticide 1971	Memorandum of Understanding	Full implementation for crop year 1972
Minnesota 4000	Commercial applicators information letters sent 1971	No	No	Memorandum of Understanding	-----
Missouri 5000	No	No	No	"Inquired of Kansas, 1970"	-----

¹All states require death occurring within the state be documented as to cause of death. In many cases these are lumped under poison.

²All states have poison control centers but accurate records of cases treated is not required by states. Any reporting is voluntary.

TABLE 17-E

<u>TITLE</u>	<u>NAME</u>	<u>DATE OF CONTACT</u>	<u>COMMENTS</u>
<u>ILLINOIS</u>			
State Entomologist, State Health Dept.	Mr. Harvey Dominite	11/4/71	No figures to indicate any reporting of agricultural workers hours, lost, sickness, nausea, etc. from this office.
Bureau of Hazardous Substances	Dr. Sues 217-525-7747	11/4/71	Not in this office.
Environmental Health Office Chief of Bureau	Mr. Verdin Randolph 217-525-6555	11/3/71	
	Mr. Stratton, Asst. Dir., Bur. of Personal Planning Health		Only through PCC.
	Mr. Rodney Anderson 217-525-3817		Analytical only. As aid to economic poisons Act, Dept. of Agriculture Interagency Committee on Pesticides.
Weed Pesticide Specialist	Mr. Hogancamp		No source information for adult exposure at this time.
Dir. of Disease Control	Ms. Mary M. Henry Adm. Assistant. 217-525-7747		Tried to identify the problem but with little success.
State Extension Specialist in Entomology	Dr. H. (Pete) Petty 217-333-6652	11/5/71	"Under custom applicator law an incident may go completely undetected." No machinery for recording illness of this type in Illinois. See additional comments in text following.

ILLINOIS
(Continued)

TITLE	NAME	DATE OF CONTACT	COMMENTS
National Safety Council, Chicago, Ill.	Mr. Sidney Smith Assistant Dir. Statistics Div.	11/4/71	No standard reporting system for pesti- cides or other non-fatal accidents.

<u>TITLE</u>	<u>NAME</u>	<u>DATE OF CONTACT</u>	<u>COMMENTS</u>
IOWA			
Dept. of Health Commissioner	Dr. Schoff, M.D.	11/3/71	Nothing from this office. No plans at present to require this reporting.
General Health Services	Dr. John Goodrich, Director 515-281-5443	11/3/71	Only mechanism is through poison control centers and on a strictly voluntary basis. This is not among the things required by law to be reported (of V.D., etc.). Suspects that PCC may be quite lax in reporting.
Coordinator, PCC	Mr. Paul Ogilvie 515-281-5445	11/3/71	May be faulty due to lack of reporting. Trying to improve.
Institute of Agr. Medicine, Univ. of Iowa	Dr. Keith Long, M.D.	11/3/71	See text comments.

MINNESOTA

<u>TITLE</u>	<u>NAME</u>	<u>DATE OF CONTACT</u>	<u>COMMENTS</u>
State Pesticide Office	Mr. Tarmann	11/4/71	-No- manually handled through PCC.
Health Dept. State of Minn.	Mr. Russell Frazier Dir. of Analytical Ser.	11/3/61	Routinely runs samples from water and wildlife from the state. . . or if specifically requested to do so.
Health Dept. Environmental Health Section	Mr. Parrell Anderson 612-378-1150 Ext. 325		No state machinery for such reporting. PCC in Minnesota primary function is to information to regional centers do fair to poor job of reporting (0-12 yrs.).
Environmental Health Section	Mr. Raschka 612-378-1150	11/2/71	Industrial injuries reported through Commerce Dept. Farmers and farm workers not covered by this or workmen's compensation in Minnesota. M.D.'s do not report occupational injury. Will undoubtedly be reported when and if state becomes of Federal Occupational Safety and Health Act.

MISSOURI

<u>TITLE</u>	<u>NAME</u>	<u>DATE OF CONTACT</u>	<u>COMMENTS</u>
St. Louis County Medical Examiner	Dr. Geo. Gantner (Ch. Dept. of Pathology, St. Louis Univ. School of Medicine		No machinery established in State of Missouri
Mo. Div. of Public Health	Dr. Wm. F. Raithel	11/5/71	Suspects are most often ignored. Food and Drug function primarily
Epidemiologist	Dr. H. Denny Donnell 314-635-4111		A new function - probably will get to it in the future. Presently have a hard enough time getting people to report syphilis and gonorrhea without something as unimportant as pesticides.

toxicity). He was finding it difficult to get orchardists to believe ethyl parathion was a poison and believed it probably was carelessly used by many. Dr. Petty has cholinesterase assays run before, during and after his demonstrations and has never suffered cholinesterase depression.

It should be pointed out that Illinois officials were courteous and as helpful as possible. (This was also true for the other four states covered). The fact remains however, that no system exists for reporting this kind of injury.

It also should be pointed out that while we are attempting to make no comparison between state programs, the educational material and short courses conducted through the University of Illinois along with an aggressive program of farmer education in pesticide in the State of Illinois appear to be quite good. The dedication of men such as Dr. Petty is undoubtedly responsible for some of Illinois' success in keeping injury to a minimum (see Table 17-E).

Iowa

Dr. Keith Long has been in charge of Institute for Agricultural Medicine for 6 years. He suspected

that reporting by other agencies is or might be faulty. As a result last year he instituted a post card survey receiving 1100 replies, 900 of which reported treatment for pesticide exposure of some kind. At the same time state poison control centers and hazardous substance centers reported only 37 cases. A more complete program of action is planned for crop year 1972. Although Dr. Long is aware that his efforts are not as well organized as Kansas alert system, he has solicited help in obtaining reports from rural medical doctors in the state.

In summary he feels the entire problem of injuries from pesticide use is of far greater magnitude than previously believed.

Particular reference and attention should be directed to these excellent studies. It appears that little will be accomplished at the state level until or unless a strong interdisciplinary program is established and funded. Of the five states only Iowa has such on-going studies and the results of this contriving program help to focus on the potential magnitude of the problem.

Kansas

All contacts from state offices indicated there was no records system, although it is felt the Poison Control Center does a very good reporting job. Unlike most other states, Kansas Poison Control Centers do report people over the age of 12 years. All contacts referred us to Mr. Roger Oxius, coordinator of the new Kansas State Pesticide Alert System. Mr. Oxius reviewed the mechanism of the memorandum of understanding (ethyl parathion) and indicated that although the state was a signatory he felt the system was too cumbersome and much too late. What was needed was to keep ahead of potential injury. Plans were initiated too late for the agricultural crop year 1971; consequently, the first alert was for rodenticide use in fall of 1971 (see Figures 6-E, 7-E, and 8-E). Full implementation of the plan for the crop year 1972 is anticipated. The plan appears to provide a workable early warning system for those concerned with pesticide use.

Minnesota

Mr. Roschka noted a little-publicized study completed summer 1971, on commercial/aerial applicator.

KANSAS STATE DEPARTMENT OF HEALTH
Edwin D. Lyman, M.D., M.P.H.
Director of Health

SPECIAL TO KANSAS DAILIES, AP,
UPI, RADIO and TV Stations
For Immediate Release
Mailed October 13, 1971

FIGURE 6-E

KANSAS PESTICIDE ALERT SYSTEM

The State Health Department's Pesticide Program and the State Board of Agriculture's Entomology Division are beginning a Pesticide Alert System. Purpose is to alert public health and medical personnel of the possible use of a potentially hazardous pesticide in their area. This will permit immediate medical treatment in cases of overexposure to the pesticides, some of which are so new that little may be known about them.

The Entomology Division monitors fields in Kansas and predicts types and areas of insect infestations, and the pesticides most likely to be used. Now these predictions will be sent to the State Department of Health. Staff will notify public health officials and physicians in the area about the probable pesticides, their ingredients, and suggested treatment in case of over exposure.

State Health Department officials remind the public that all pesticides should be used with care, following instructions on the label.

The Pesticide Alert Bulletin mailed October 8 lists rodenticides for rats and mice seeking warmth as Winter approaches. The list and treatment chart have been mailed to local health departments, hospital emergency rooms, and poison control centers.

KANSAS STATE DEPARTMENT OF HEALTH

FIGURE 7-E

MEMORANDUM

To: Local Health Departments, Poison Control Centers and Hospital Emergency Room Supervisors
From: Virginia Lockhart, Director of Health Education, Kansas State Department of Health
Subject: Current Information Regarding Emergency Medical Treatment for Acute Pesticide Poisoning

Attached is current information regarding emergency treatment for cases of acute pesticide poisoning. We are sending this information to you as part of our state-wide "Pesticide Alert System". This system is a cooperative activity of this agency, the Entomology Division, State Board of Agriculture and the local health departments.

The Entomology Division through its regular surveillance of fields in the state is able to predict insect build-up, the period of time the insects will be a problem and what pesticides will be used to combat them. This information will be provided on a regular basis to this office. We will promptly notify local health departments in the counties under the alert who in turn will notify physicians and hospitals in their county. In this way the information of possible danger from misuse of pesticides will be promptly available to medical personnel in the affected counties.

We suggest that the attached chart be placed in the emergency rooms of hospitals and posted on the walls of the poison control centers.

Please let us know if you have questions or encounter problems.

VPL:np

FIGURE 8-E

PESTICIDE ALERT BULLETIN No. 1

With Winter approaching, members of the rodent family, especially rats and mice, will be seeking warmer climes. In doing so they will be entering buildings, and a resultant increase in the use of rodenticides should be expected.

The Kansas State Department of Agriculture has notified us that the following chemicals are recommended for use against pests and will soon be used to effect their control:

<u>Rodenticide</u>	<u>LD₅₀ (mg/kg)</u>
Fumarin	25
Pival	50
Warfarin	186
RoZol	-
Diphacin	5
1080	5
Valdan	-
ANTU	6.5
Red Squill	150
Zinc Phosphide	40
Strychnine	1-30

Please refer to the enclosed treatment chart in case of poisoning by one of these materials.

Roger Ozias
Pesticide Program
Kansas State Department of Health
10-8-71

use patterns. The results of that study, although somewhat limited in scope, are nevertheless, very interesting. It would appear that aerial applicators in Minnesota are aware of potential harm from the use of phosphate insecticides although they seldom realize how dangerous (only 40 percent over more respirators). The group in which the greatest possibility for harm exists appears to be ground crewmen hired to assist applicators. These people, usually of college age, are of limited experience and probably quite naive about the potential for harm. Unless specifically required to take pesticide measurements, they probably would not. The study concludes by presenting information to suggest that ground insecticide sprayers, because of a lack of rigorous requirements by the State Department of Agriculture, may well constitute the groups possibly subject to greater harm from phosphate insecticides than aerial sprayers.

For the first time in Minnesota a somewhat effective liason has been established between a state agency (Department of Health) and the prospective target (commercial aerial and ground applicators). Plans for the crop year 1972 include an intensive educational and informative effort.

Missouri

At present, Missouri has no mechanism for reporting or recording incidences resulting from pesticide use, primarily because it simply has not been regarded as sufficiently important.

In summary the states in the study area appear to have rather poor means of identifying the problem of health hazards from pesticide use if it in fact does exist. The Kansas Alert System appears to be a step in the right direction; for the best effect pre-season estimates of possible insect infestation must be as accurate as possible. There is a multi-pronged result involved here: a closer working arrangement; prediction of possible hazards to human health; valuable recommendations on pesticide application rates, if forecasts are valid; and, consequently, tremendous potential dollar savings to farmers and decreased hazard to the environment.

Armed with information from the state officials, the Iowa Institute of Agricultural Medicine and a Minnesota customer applicator survey, many of the questions previously posed still remained unanswered. The contractor then initiated a survey of 1600 outstate medical doctors to better characterize the nature of potential harm to farmers and farm workers. The results

are tabulated in Table 18-E. Twenty-five percent of the doctors responding indicated they had treated patients for pesticide-related symptoms. Of these, 65 percent were from organo-phosphate poisoning. When one considers that respondents were rural doctors only, that farmers could and probably do seek medical help in larger cities, and that farmers are not apt to seek any medical help for milder symptoms, the numbers are regarded as significantly lower than the real total. Replies recorded were slightly less than 20 percent of the number of contacts. Assuming a random response, these figures are probably five times lower than the real totals.

As part of the contractor's information gathering efforts, all states were requested to supply data from their respective poison control centers or State Bureaus of Vital Statistics. Not all states replied and as noted earlier, none had identical or correlative reporting methods. A break down of poisonings by cause is beyond the scope of this project but it is noted here that along with an increase in the total number of poisoning, incidences for pesticides and rodenticides as a SLS group appear to be increasing, as shown in Table 19-E. The general increase in poisoning incidences observed in Kansas is a primary reason for the development of the Alert System.

TABLE 18-E

RESPONSE OF OUTSTATE MEDICAL DOCTORS TO SURVEY OF PESTICIDE
RELATED INJURY TO HUMANS, 1970-1971

State	Response (1)		Incidences (2)					Unspecified or Other
	Yes	No	Organo- Phosphate	Chlorinated Hydrocarbon	Mercury	Arsenic		
Illinois	21	69 (90)	(14) 53	--	17	24	2	
Iowa	13	39 (52)	(8) 19	--	1	1	3	
Kansas	11	30 (41)	(11) 29	--	--	1	--	
Minnesota	22	56 (78)	(9) 61	4	6	9	7	
Missouri	16	45 (61)	(8) 46	1	22	16	3	
TOTAL	83	239 (322)	(50) 208	5	46	51	15	

¹Number in parentheses indicates total responses from each state.

²Under organo-phosphate; the number in parentheses indicates number of doctors reporting incidences. The number following indicates number of patients seen or treated for this cause of injury. Thus, (14) 53 means that 14 doctors treated 53 patients for organo-phosphate poisoning.

TABLE 19-E
REPORTED POISONING INCIDENTS FOR THE
FIVE STATE STUDY AREA

Year	Total (Poisonings)	Pesticide/ Rodenticide	Frequency Index
1968	1671	61	365
1969	2101	75	357
1970	2345	131	560
1971	1658*	73	(440) about 800 projected

*Data for first two quarters only (i.e., 1/2 year).
Projections for 1971 surpass 1970 by Frequency Index
when summer applications of pesticides are included.

Data from the State of Illinois shows some change in the total number of incidents, especially for the year 1971. This may reflect increased activity, awareness, safety programs - but the role of these factors cannot be verified.

As might be expected, there are significant increases in incidences in the summer months of June, July, and August, although the number reported for each month remain consistent for the period of examination (1966-1970). Surprisingly, incidents from certain formulations, i.e., moth balls, cakes, etc., do not show

TABLE 20-E

ILLINOIS POISON CONTROL CENTER DATA
Downstate - Excludes Cook County, Chicago

	Insect.	Rod.	Herb.	F.	Moth.	Other
1970	141	175	16	-	66	7
1969	180	178	12	-	72	4
1968	181	163	20	1	73	5
1967-1966 - No break down						

NOTE: Most of insecticides are roach, ant, fly bait spray. Many (most) of incidences seem inordinately high - really only a report - no symptoms, no after effect - child found with box, contents, on surface of skin - no way of telling how much if any was ingested.

dramatic seasonal distributions as might be expected. Analysis of monthly records show that these types of poison are available at all times of the year but for differing circumstances; for example, in fall and winter, children encounter the preparations when playing indoors on the floor, in closets, in, under, around, and behind furniture, etc. These incidents occur until late in the spring when parents begin to store woolens. The preparations are then encountered when parents carelessly leave them unattended. Later, in late summer or early fall, as woolens are removed from storage and shaken out, the preparations can fall, unnoticed, from clothing and roll under furniture or next to baseboards.

Here the child encounters and ingests them. Thus, throughout the year, these formulations account for a fairly consistent monthly percentage of the total.

The same pattern is observed for mouse and rat baits. As rodents enter homes in the fall and early winter, more of these "baits" are purchased and laid out where they are subsequently discovered by children. Spring house cleaning and late spring and summer airing of homes apparently uncovers once-carefully placed baits, many apparently on the way to disposal when they are ingested by playing children.

Roach baits of different formulations are rather uniformly ingested, on a monthly basis, perhaps a reflection of the ubiquitous nature of the pests in its almost daily association with man.

The months of June, July and August universally show an increased level of incidents due to agricultural type pesticides. Analysis of these records show a marked increase in the contact of children with preparations used against flying insects, garden and lawn pests, and, particularly, preparations designed for use against ants. The number of incidents rather clearly reflects increased exposure at this time of the year.

Only a few cases were reported in which the product in question caused harm when used as directed. Ant,

roach, and mouse preparations are obviously not placed sufficiently far from agile fingers of curious children.

Nationally known insecticides and herbicides are conspicuously absent from incident lists, which may be a reflection of more or less adequate precautions for the purchaser. (See labeling and packing directions elsewhere). The most disturbing exception is when contents are transferred from original containers to temporary packages - such as soft drink bottles - for use by other people, a flagrant violation of the packing directions for which the manufacturer or formulator cannot be held responsible. The most tragic accidents reported have been to children ingesting the contents of such bottles.

The annual report of the Iowa Community Pesticide Study (FDA-70-17) should also be consulted for referrals. Some cases of documented pesticide exposure and resulting illness show an intimate relationship between the two.

It should be noted it is extremely difficult to document and medically distinguish true pesticide poisoning from other human illnesses. However, lack of proper caution is indicated in a great number of cases.

A large part of the medical effort in these studies is being directed at possible subtle behavioral changes (nervousness, agitation, disorientation, etc.) which

could possibly be the result of chronic low level exposure to pesticides.

The existing mechanisms for reporting injuries from accidental exposure to agricultural pesticides in the five study states and the attitudes maintained by the respective states is, at worst, reprehensible, and at best, subject to close scrutiny (see summary chart, Table 16-E).

While pesticide exposure may be difficult to separate from other common ailments, only one of the study states has a adequate program to identify and quantify the extent of possible harm resulting from use or misuse of pesticide formulations. The survey of farm agents strongly suggested that phorate was responsible for rather severe headaches and nausea when the dust drifted back onto the applicator. Careless application of ethyl parathion by some orchardists resulted in severe nausea. Yet neither of these obvious examples are reported through channels to state medical authorities. Nor does the National Safety Council (headquartered in Chicago, Illinois) keep nation-wide statistics on illness of injuries or fatalities involving pesticides.

Farm Injury - Livestock

Contacts with veterinarians and other state offi

cials by the contractors has indicated that there is no adequate system for reporting or caring for farm animals so injured. In many cases in-field diagnosis of organo-phosphate poisoning to livestock is faulty or called for after death so that valid measurements cannot be made. The general philosophy seems to be that 'a dead cow is a dead cow! Besides who is going to pay for the analyses of blood, tissue or gut contents after it's dead!

Although local attempts may be made to identify and characterize injury these items do not have to be specifically reported by law and hence, usually are not.

The Iowa Community Pesticide Study

Through a system of alerting local practicing veterinarians is solicited such support and as a result, cases are referred. This system of local referrals, clinical diagnosis, and treatment and carefully executed physiological and neuro-physiological investigations presents some thought provoking and sobering data. In Iowa alone, hundreds of farm animals have suffered some kind of debilitation (usually death) as the result of contact with pesticide compounds. Additional hundreds have suffered

loss of production, reproductive failure or death from a variety of other agricultural chemicals.

It should be pointed out that a large number of the cases were and probably continue to be the result of gross misuse and carelessness in the use of these compounds.

Aquatic Ecosystems

Adequate reporting and recording of local incidences of pesticide "damage" to the waterways has not been conducted by any of the five study states. Based on interviews with county and farm service agents, the problem appears to be extremely minor. However this attitude reflects the general feeling that pesticides are vital to maintain and improve crop yields.

In all cases, reported incidences to farm water, stock water, creeks, and ponds represent one percent of the total water involved in the farm. Although dead fish and invertebrates are observed they are seldom reported (see causes of problems). This attitude is borne out by federal reports of fish kills due to pollution of all types which are filed, only when the incident is sufficiently great or is seen.

Farm ponds tend to be located where grass covers most of the watershed and intensive agriculture is

not practiced. The potential for unreported damage to creeks and smaller flowing bodies of water is thus poorly documented. In most documented cases, carelessness and/or unexpected heavy rainfall during application periods are responsible.

County farm agents were surveyed to assess the extent of possible pesticide damage to farm water supplies, especially the aquatic ecosystem. Not surprisingly, a very small number of incidents were reported, as shown in Table 21-E.

TABLE 21-E
LOCATION OF POISONING INCIDENTS, FIVE-STATE AREA

<u>Poison Incident</u>	<u>Illinois</u>	<u>Iowa</u>	<u>Kansas</u>	<u>Minnesota*</u>	<u>Missouri</u>
Farm pond	34	6	18	13	18
State Water	14	7	2	6	4
Creek or Stream	31	10	5	2	14
Other-Includes well poisoning by back siphoning, etc.	1	0	2	0	4
Approximate Number of Ponds in Survey Area Approximately 1/4 to 1/2 acres	19,714	12,470	42,026	8,140	69,462

*Minnesota figures mean little here in that of the area and agents surveyed in excess of 200,000 acres is natural water.

Considering the total number of ponds involved in the area these figures appear to be quite low. However, natural reluctance by the land owner to admit carelessness is involved. Also, it appears some farm agents carefully avoid knowledge of the problem due to damaging press coverage pesticides have thus far received. One authority who wished to remain anonymous indicated that agents in one state were specifically instructed not to report pesticide incidents.

State conservation officials were also contacted and although they declined to cite figures, all of them indicated that the figures received from county agents were far too low - by at least a factor of 10. Estimates of state officials were based on complaints to local conservation agents, which are not tabulated or recorded by state agencies.

Reports to Federal Water Pollution Control Association and Environmental Protection Agency for the period 1960-1970 do not cite pesticides as a major contributor to fresh water fish kills. Despite improvements in the reporting system, it is questionable if it will be adequate to effectively monitor potential damage to public water.

To more adequately assess the extent of damage the contractor requested each state to provide the field

notes for a typical annual report (1970). Illinois declined, indicating a majority of the cases were still in litigation and the public exposure might bias the court or endanger the litigants. Examination of the reports received did give a better insight into the field reporting of incidences. However they also failed to implicate pesticides to any greater extent than the federal reports.

Headlines such as INSECTICIDES KILL 500,000 FISH IN X CREEK. . . appear to contradict the reports cited above. However, when one investigates it is found that this figure represents 400,000 small forage fish, 95,500 rough fish and fewer than 5,500 valuable game fish. Thus the impact of a headline such as this is far out of proportion to the real dollar value of the fish involved.

The point which most often is overlooked is that the product, in question if properly transported and used in the manner intended might not directly result in death or a reduction in the aquatic population.

Table 22E shows 1969-1970 fish kill data for the five state study area.

TABLE 22-E
FISH KILLS DUE TO VARIOUS FORMS OF POLLUTION IN
FIVE STUDY STATES (1969-1970)

Operations Code	Pesticides (11)	Fertilizer & Feedlot (12 & 13)	Food Processing (22)	Mining (21)	% from Other Causes
Illinois					
1969	8.0+%	43.0%	35.0%	6.0%	(84)%
1970	-	32.0	7.0+	26.0	(65)
Iowa					
1969 (1)	-	-	-	-	
1970 (2)	Some	Some	-	-	
Kansas					
1969	3.0+	24.0	0	50.0	(75)
1970 (3)	50.0	45.0	1.0	-	(96)
Minnesota					
1969 (4)	66.0	0	3.3	-	(30)
1970 (5)	74.0	0	Heavy	-	(05)
Missouri					
1969 (6)	1.0	50.0	14.0	1.0	(65)
1970	1.0	1.0	22.0	30.0	(53)

All values approximate from Federal Report of the number reported.

Numbers in parentheses refer to numbered comments (1-6).

The basic inadequacies of the reporting system become apparent when the following factors are examined.

1. The report of no losses from pesticides, feedlots, fertilizer and/or food processing industries for Iowa in 1969.
2. An undetermined number of fish died from pesticides and feedlot wastes. Since no numbers are indicated the values that we reported bias the sample. The losses were indicated to be of 1 and 2 severity.
3. Pesticides were suspected in the death of over 60,000 fish from Marion Reservoir, this was later confirmed by Dr. Klassen, Kansas State University. The kill was reported as due to undetermined causes (90). An additional 40,000 fishes were killed probably as a result of pesticides used in a sewer plant to kill larvae. This was reported as a sewer plant incident. Thus, 50 percent of the 1970 total kill was attributable to pesticides but not reported in 1969.
4. Sixty-six percent of a total state kill was attributable to pesticides in 1969.
5. The 1970 report lists no numbers for the

Zumbro River kill but state officials indicate that it was an extremely heavy kill - food processing was the cause. The Roseau River kill was also due to pesticides and was, in the opinion of the reporting officer, probably twice as extensive than reported.

6. Officials from Missouri indicate that the reported figures are probably far too low for pesticide incidences.

As a general comment, far too many causes are calssified as "other" to properly assess damage from any category. This is not a result of any state directly trying to minimize the damage from a specific cause. In most cases responsible state officials were not notified of the kill(s) until days had passed. Fished were often found after suspected material(s) diluted to a point where analysis was impossible or impractical.

The real losses reported from the four listed causes, fertilizer, feedlots, food processing, and mining (12, 13, 21, 22) account for the major causes of fish kills in Missouri, Kansas, Illinois, and Iowa for 1969 and 1970. An inescapable fact is that losses from pesticides are rather insignificant when compared to the losses due to sloppy agricultural practices, feed-

lots and industrial causes.

It is the feeling of the contractor that reports of losses of fish in farm ponds is so poorly documented and represents such an insignificant quantity that it will not be reported here. In terms of total pesticide incidents, Minnesota represents a very badly biased sample.

Farm agents appear to be aware of the desirability of reducing erosion losses to keep pesticides where applied as well as a generally sound agricultural practice. However most are also aware that this is not financially practical at present.

It is difficult to impress agents with the significance of pesticide damage to the aquatic ecosystem when he is aware of the effects of fertilizer and feedlot damage and the other listed causes. Pesticides, are responsible for less than 10 percent of the total losses (except in Minnesota, where the total number of animals is rather small), while feedlot and fertilizer damage may run up to 50 percent of the total. In Missouri mining practices account for up to 50 percent of the total fish kill reported.

Most agents (80-90 percent responding) believe pesticides could be made safe (or safer) for land and water if manufacturers directions were carefully fol-

lowed. All pointed out that a certain level of carelessness could be expected, no matter what the directions said. Gross misuse was cited as the major cause of identified or potential harm. The general feeling was that most farmers honestly tried to follow directions and that for the most part, directions were adequate. Interestingly, agents from all states felt that more meaningful information could and should be provided by state departments of agriculture for local conditions and needs.

Many agents felt that industry and urban and suburban homeowners were responsible for a far greater share of the total problem than independent farmers.

Summary and Conclusions

Very little is known about the effects of various pesticide compounds on the total aquatic environment. Part of this general inability to properly assess environmental damage comes from the lack of sufficient knowledge of the intimate, subtle and extremely complex functioning of aquatic ecosystems. Sufficient information is presently at hand to indicate that environmental damage has occurred, is occurring, and despite what we do now, will continue to occur for some period of time.

The contractor feels sufficient knowledge is at hand now to set forth the following summary and conclusions relating to impact on the aquatic environment.

Persistent pesticide compounds do not disappear after application. They may remain for variable periods of time, hopefully fulfilling the task that they were designed for: the destruction of agricultural pests, potential disease vectors, and other noxious pests of all varieties. Concomitant with application and again for varying periods of time and at differing rates, these compounds co-distill, vaporize, adsorb on inorganic and organic particles and are absorbed into living material where they may be altered chemically, exert an often unidentified influence over the

living tissue, be stored with no apparent harm, or eliminated to the environment.

It has been shown that some kinds of pesticide compounds have been found in almost every kind of living material when looked for. The key word here is when, for many of our informational gaps are the result of simply not having had the time or the money or the experience to measure all aspects of our global biota. It is significant that no ecosystem, terrestrial or aquatic, has been found free of these compounds no matter whether it be simple or complex. It is also well to remember that even the most "simple" ecosystem has, upon closer inspection, been found to be extremely complex. It can truthfully be said that we really do not fully understand the complete biochemical or molecular nature of even the most "simple" such system. It is highly unlikely that we ever will.

Implicit in an appreciation of the trophic dynamic structure of any ecosystem is the concept that, in addition to energy, other compounds are transferred from one trophic level to the next. One of the difficulties in developing a full appreciation for pesticide involvement in trophic structure is that any trophic level

can and does acquire additional qualities completely independent of any other level. This is accomplished most commonly by ingestion or absorption from the surrounding environment.

Thus we find that the primary producer group of photosynthesizing plants of the aquatic environment have the ability to accumulate these compounds from the water. The metabolism and the degree of degradation accomplished by these plants is poorly understood at this time. Although not all groups respond in the same fashion, some exposures have resulted in a reduction of photosynthetic rate in both marine and fresh water algae.

Zoo plankton have shown a variety of responses to pesticide exposure. Species susceptibility within the same taxonomic group varies from almost no effect to complete intoxication and death at similar exposure levels. Although some experiments have been conducted and many more are either being conducted now or planned for the future, our knowledge of the response of natural populations of zoo planktons to environmental levels of pesticides is quite inadequate. Long term chronic exposure to sub-lethal "natural" levels as are being conducted by the Federal Fish Pesticide Laboratories and

independent investigators are vitally needed to identify effects on longevity, productivity, and intrinsic rates of natural increase. Such additional information is required to properly assess the effects of environmental variables, such as temperature, pH, water hardness, and other water quality factors, and the synergistic effects of combinations of other potentially harmful compounds. Prodigious quantities of these organics are consumed by higher trophic levels. The combined production of zoo plankton must be maintained to support sustained yield of higher forms. A significant degree of biomagnification is observed by virtue of the critical quantities consumed as well as from the environment.

Benthic organisms like some zoo planktons now occupy different trophic levels depending upon their age and life style. Vegetarian species are obviously primary consumers, while omnivores or strictly carnivorous species may be primary consumers as young or primary or secondary consumers as adults.

The literature is clear that these forms can accumulate pesticide loads far in excess of the levels below them. Considerable species variation as well as differences between genera and family can be seen relative to the ability to "withstand" certain levels of pesticides.

At the present time, an insufficient number of different organisms have been examined carefully enough to identify the effects of long term sub-lethal exposure. Frequent examples of virtually complete denudation of streams have been observed following heavy applications of pesticides. Repopulation of these diminished areas within a year are given as evidence of no real harm. Repopulation by this nominally very mobile group of crustaceans and essentially aerial insects should not surprise anyone. We do not know what effects chronic sub-lethal exposure has on rates of feeding, food conversion, reproductive success or growth and longevity. Basic experiments which have been performed suggest that sub-lethal exposure for periods of up to one or two hundred days are harmful to zoo planktons and benthic forms in terms of growth and viability. Higher trophic levels are usually composed of vertebrate organisms. The smaller members (minnows and other forage fishes) usually have a relatively short life. Thus, individually they may not accumulate a tremendous body burden during their lifetime. Larger organisms (predaceous and piscivorous fishes) live longer and consumer many smaller organisms, thus accumulating much higher burdens in their lifetimes. One of the things that

is so difficult to assess in the aquatic ecosystem is relative lack of fitness. If organisms from any trophic level have been weakened or debilitated in any way, they are far more susceptible to capture, disease, or parasitic infection. The possible effects of low level chronic exposure resulting from potentially harmful pesticides are more easily eaten and thus removed from our scrutiny.

Larger aquatic vertebrates have generally been studied longer and have more known about them than the lower trophic levels. This fact, plus the fact that they are usually economically more valuable to man, has resulted in a considerable body of information on pesticide effects to this group. Admitting that acute exposure levels are necessary to establish guidelines for water quality and to protect the stocks of fishes to some extent, we would nevertheless like to stress the results of chronic sub-lethal exposure.

It has been demonstrated that long term sub-lethal exposure to some chlorinated hydrocarbon compounds does produce teratogenic effects in a number of valuable species of fishes. The extreme case is demonstrated by the loss of entire broods of Atlantic salmon at the time

of hatching, following exposure of the parents. Numerous examples harm warm water fishes, particularly pond stocks of channel catfish, show increased levels of malformed and dead young, resulting from exposed parental stocks. Transovarian movement of many of these compounds have been demonstrated for mammals, birds and fishes; it is assumed to be a vertebrate phenomena varying only in degree between class and species.

It appears that behavioral abnormalities can result to fishes from exposure to chlorinated hydrocarbons. Some of the experiments at very low sub-lethal levels are only noticed when the most sophisticated electro-physiological measurements are conducted. The fact that many lay people do not understand what this kind of technology means does not detract from the potential for harm to these organisms. Likewise learning behavior has been reported as lessened in chronically exposed fishes. No data is available for other aquatic life.

Endocrinological alteration, especially in pituitary and adrenal function, have been noted. These effects may have far reaching effects on the life of individuals as well as the perpetuation of the species.

Hepatic microsomal enzyme induction has been recorded for other vertebrates as well as for fishes.

The resulting disturbance of steroid metabolism is well documented. Evidence has been presented which indicates that variations in respiratory rate affect the uptake of certain chlorinated hydrocarbons. We know nothing about the pharmacodynamics of uptake or diffusion rates as they relate to variations in water chemistry. Alterations in protein metabolism have been demonstrated in fishes and other vertebrates. This may be a reflection of the hepatic microsomal enzyme response. It may be particularly important in fishes as a vertebrate group since these animals seem to be adapted specifically to the metabolism and elimination of nitrogenous compounds.

Some of the most striking effects to fishes have been the result of studies which showed no apparent harm under regimens of chronic sub-lethal exposure. When starved or when conditions exist that require the animal to draw on body stores of fat or protein for energy, the resulting concentration of stored material exerts its effect; reduced vitality, decreased muscular ability, disturbed metabolism and death are observed.

Research in metabolism of cold blood organisms have lagged behind mammalian and bird studies. Little is known of how fast or to what extent body stores of fat are mobilized by stressed aquatic organisms. Serious

question is raised as to the suitability of acute and chronic exposure studies in aquatics as they have been conducted. Certainly additional research is required in this area.

Osmoregulation and osmoregulatory ability is more of a problem with aquatic animals than terrestrial. It is for this reason that alterations in kidney function and disturbed osmoregulatory ability under conditions of chronic exposure to chlorinated hydrocarbons pose such a threat to this group.

The choice of experimental animals is often dictated by availability as much as general suitability. Although mechanisms do exist at the Federal level for specifying the nature of information to be supplied the manufacturer for registration of a compound, it is felt that these criteria are in need of complete revision and certainly must be expanded to include experiments and measurements designed to better sense the impact on the environment. In this connection it is particularly important that additional non-target species be included.

Those organisms which constitute the decomposer group (bacteria, fungi, and other microbes of soil and water) have been demonstrated to exert a limited effect on the degradation of persistent pesticides in natural

environments. Under laboratory conditions, groups have been identified which will degrade to some extent; often the degradation products are more toxic than the parent compound. Our total information in this area, particularly from natural environmental conditions, is particularly meager.

The literature is clear in the picture it presents of global contamination of our abiotic and biotic ecosystems. All trophic levels carry body burdens -- whether the persistent compounds kill outright or only reduce trophic level efficiency is still open to question. In any event, it is clear that biomagnification does occur between successive trophic levels, additional bioaccumulation can and does occur at each trophic level. The result is one of sufficient body burdens of these compounds at the highest levels to cause death, debility, reduced reproductive success, reduced mental alertness and a generally disturbed physiology, all tending to reduce the biological fitness of the animal to meet the demands of the environment.

Studies with laboratory mammals suggest the possibility of harm to the human animal. It must be stated that no adequate demonstration of clinical manifestation of carcinogenicity, mutagenicity or teratogenicity has been shown for humans, resulting

from chlorinated hydrocarbon exposures at low levels commonly encountered in the environment.

Acute toxicity has been demonstrated with some compounds at high levels and should not be surprising in view of their poisonous nature.

There is mounting evidence of past careless use of organo-phosphate compounds. Clearly industry and all segments of agriculture and agribusiness must dedicate themselves to better education of the users of these chemicals. Additional research is urgently needed to make use and particularly application safer for the general user.

Farm Injury - Human

County agents, farmers and doctors in the five study states were surveyed to determine the extent of possible harm to farmer/applicators from the handling of pesticides. About twenty-five per cent reported knowledge of particular incidences of pesticide-exposure-related illness within the past year. Twenty-five per cent of the doctors responding indicated they had treated patients for pesticide-related symptoms. Of these, 65 per cent were from organo-phosphate poisoning.

The greatest causes of illness were: (1) spray drifting back on the operator; and (2) contact with pesticide due to mechanical breakdown of the equipment. Phorate and disulfoton fumes were most often singled out as being responsible for operator illness. In all cases reported by County agents, operator carelessness was blamed as primarily responsible for the exposure to pesticide. In many cases agents indicated they had cautioned farmers to use protective clothing, but the warning went unheeded. These results confirm earlier reported findings that most accidental exposures are the result of improper application or obvious disregard of adequate safety measures. Containers and label

directions, although superficially adequate, do not draw sufficient attention to the dangers or are not practical for the farmer to follow. This situation, compounded by the applicators' reluctance to utilize safety clothing, plastic gloves, respirators, etc. create a potentially hazardous medical situation.

The contractor contacted state health officers or offices and/or state officers in charge of poison control centers, state pesticide officers, vector control authorities, state veterinarians, bureaus of hazardous substances and similar agencies in each of the five states. Representatives of these agencies were asked: (1) Are there pesticide-related illness not being reported? (2) Are doctors reporting pesticide-related illness to health agencies? and (3) What kinds of damage to wildlife and livestock go unreported?

Illinois

There is a lack of machinery and enforcement for reporting pesticide-related illness. No systematic procedure exists for reporting this kind of injury, however, the educational material and short courses conducted through the University of Illinois, along with an aggressive program of farmer education, appears to be quite good.

Iowa

Dr. Keith Long of the Institute for Agricultural Medicine conducted a postcard survey of farmers. Of the 1100 replies, 900 reported treatment for pesticide exposure of some kind. For the same time period, poison control centers and hazardous substance centers in the State of Iowa reported only 37 cases. These results indicate the entire problem of injuries from pesticide use is far greater in magnitude than previously anticipated.

Kansas

All contacts from state offices indicated there were no records system other than the Poison Control Center. Kansas has initiated the Kansas State Pesticide Alert System to provide a workable early warning system for those concerned with pesticide use.

Minnesota

A study of commercial/aerial applicators completed in the summer of 1971 indicated that although these men are not fully aware of the potential harm from the use of insecticides, ground crewmen hired to assist applicators have the greatest possibility of harm.

However, good insecticide sprayers, because of a lack of rigorous enforcement from the State Department of Agriculture, are subject to greater harm than aerial sprayers.

Missouri

At present, Missouri has no mechanism for reporting or recording incidences resulting from pesticide use.

In summary, the five study states have rather poor systems for identifying the problems of health hazards from pesticide use. It is significant that none of the states has a standard reporting system for injury or illness related to pesticide exposure. The Kansas Alert System appears to offer the pesticide user: (1) a closer working relationship between various involved agencies; (2) prediction of possible hazards to human health; (3) valuable recommendations on pesticide application rates; and (4) potential dollar savings to farmers and decreased hazard to the environment.

Farm Injury - Livestock

Contacts with veterinarians and other state officials by the contractor has indicated there is no adequate system for reporting or caring for farm animals exposed

to pesticides. In many cases, field diagnosis is inaccurate and after death of the animal, measurements are usually not made. The general philosophy seems to be that "a dead cow is a dead cow -- who is going to pay for an autopsy."

Damage to the Aquatic Ecosystems

Adequate reporting and recording of local incidences of pesticide "damage" to the waterways does not exist in the five state study area. Although dead fish and invertebrates are observed, they are seldom reported. This attitude is borne out by Federal reports of fish kills which are filed only when the incident is sufficiently great.

County farm agents were surveyed to assess the extent of possible pesticide damage to farm water supplies. Not surprisingly, a very small number of incidences were reported. State conservation officials contacted declined to cite figures but all indicated that the County Agent reports were far too low.

Reports to the EPA for the period of 1960-1970 do not cite pesticides as a major contributor to fresh water fish kills. Pesticides are responsible for less than 10 per cent of the total losses (except in Minnesota,

where the total number of animals is rather small), while feedlot and fertilizer damage may run up to 50 per cent of the total. In Missouri, mining practices account for up to 50 per cent of the total fish kill reported.

Despite improvements in the reporting system, it is doubtful if it will be adequate to effectively monitor pesticide damage to public waters.

Recommendations

The contractor recommends that additional effort be expended to achieve the following:

1. Understanding of the mechanisms by which pesticide compounds are adsorbed by photosynthesizing plants is achieved.
2. Virtually a total lack of information on the cellular responses of green plants and diatoms to pesticides exists. This includes information on binding sites, specific affinities for membrane surfaces, mode of action.
3. Community structure, natural succession, growth, viability and reproduction as well as the response of photosynthetic rate to pesticide exposure for a much larger variety of aquatic plants at levels currently found in the environment as well as experimental levels is necessary.
4. There appears to be a great need for basic experimental designs which would identify not only biomagnification but long term effects which would follow reproductive success for several generations.

5. Effects of long term sub-lethal exposure on growth, reproduction and viability of a much wider variety of benthic organisms.

6. Identification of cellular routes of entry of pesticides with benthic forms.

7. Elaboration of metabolic degradation pathways of pesticide compounds in benthic animals.

8. Information of effects of chronic sub-lethal exposure to major food items of top trophic levels. These include larger crustaceans, small fish, minnows, frogs, toads, salamanders, etc.

9. Much additional information on all aspects of physiology of fish exposed to chronic sub-lethal exposures of pesticides.

10. New and expanded criteria for scientific information required of registration. These criterial should be more pertinent to impact on chronic exposure to larger varieties of non-target species.

11. Expand studies on effect of soil and water microorganisms which may degrade persistant compounds and which may themselves be effected in such a way as to not perform their ecological function as we now know it.

12. Much additional information required on rates of excretion and particularly differential turn-over

rates between different animal groups.

13. Model ecosystems probably have lower values in predicting the fate of certain compounds. Such modeling should be continued with trophic dynamic considerations and attempts at balance equations.

14. Although models have their place, there is no substitute for field studies. These should be expanded to include more in-depth studies of specific watershed and basins and a much wider variety of aquatic ecosystems.

15. Expanded programs to identify the potential for harm to humans from both chlorinated hydrocarbons and organo-phosphates. State support should be solicited.

16. Expanded educational efforts on use and application as well as health hazards involved.

Industrial support is needed to develop safer compounds; this may include new technology aimed at safer handling practices and formulations.

17. Agricultural engineering might provide new and innovative methodology for application of pesticides.

LITERATURE REFERENCES

- 1 Bloom, S. C. and S. E. Degler. Pesticides and Pollution. BNA Environmental Management Series. Bureau of National Affairs, Inc., Washington, 1969.
- 2 Johnson, D. W. Pesticides in Fishes -- A Review of Selected Literature. Trans. Amer. Fish Soc. 1968. Pp. 398-424.
- 3 Carson, R. Silent Spring. Houghton Mifflin Company, Boston, 1962.
- 4 Robinson, J., A. Richardson, A. N. Crabtree, J. C. Carlson and G. R. Potts. "Organochlorine Residues in Marine Organisms". Nature 214:1307-1311, 1967.
- 5 Kapoor, I., R. L. Metcalf, R. F. Nystrom and G.K. Sangha. "Comparative Metabolism of Methoxychlor, Methiochlor, and DDT in Mouse, Insects and in a Model Ecosystem", J. Agr. Food Chem. 18(6):1145-1152, 1970.
- 6 Harrison, H.L., O. L. Loucks, J. W. Mitchell, D. F. Parkhurst, C. R. Tracy, D. G. Watts and V. J. Yannacone, Jr. "Systems Studies of DDT Transport", Science 170: 503-508, 1970.
- 7 Eberhardt, L.L., R. L. Meeks and T. J. Peterle. "Food Chain Model for DDT Kinetics in a Freshwater Marsh", Nature 230:60-62, 1971.
- 8 Morris, R. L. and L. G. Johnson. Pesticide Levels in Fish From Iowa Streams. State Hygienic Laboratory Report #71-4, 1970.
- 9 Morris, R. L. and L. G. Johnson. Pesticide Levels in Fish from Iowa Streams. State Hygienic Laboratory Report #71-23, 1970.
- 10 Morris, R. L. and L. G. Johnson. Pesticide Levels in Fish and Bottom Silts from Iowa Streams. State Hygienic Laboratory Report #71-10, 1970.
- 11 McDonald, P. Personal communication.
- 12 Rudd, R. L. Pesticides and the Living Landscape. University of Wisconsin Press, Madison, 1970.
- 13 Detwyler, T. R. Man's Impact on Environment. McGraw-Hill, Inc., New York, 1971.

- 14 Broughey, A. S. Man and the Environment. The MacMillan Company, New York, 1971.
- 15 Hartley, G. S. and T. F. West. Chemicals for Pest Control. Pergamon Press, London, 1969.
- 16 Report of the Study of Critical Environmental Problems (SCEP). Man's Impact on the Global Environment. M.I.T. Press, Cambridge, 1971.
- 17 Graham, F., Jr. Since Silent Spring. Houghton Mifflin Co., Boston, 1971.
- 18 Burnett, R. "DDT Residues: Distribution of Concentrations in Simento analoga (Stimpson) Along Coastal California". Science 174:606-608, 1971.
- 19 Risebrough, R. W., D. B. Menzel, D. J. Martin, and H. S. Olcott. "DDT Residues in Pacific sea birds: a persistent insecticide in marine food chains". Nature 216:589-590, 1967.
- 20 Woodwell, G. M., C. F. Wurster, and P. A. Isaacson. "DDT residues in an East Coast estuary: a case of biological concentration of a persistent insecticide". Science 156:821-824, 1967.
- 21 Sprague, J. B. and J. R. Duffy. "DDT Residues in Canadian Itlantic fishes and shellfishes in 1967". J. Fish. Res. Bd. Canada 28:59-64, 1971.
- 22 Vance, B. Dwain and W. Brummond. "Biological concentration of pesticides by algae". J. Amer. Water Works Assoc. 61(7):360-362, 1969.
- 23 Hannon, M.R., Y. A. Greichus, R. L. Amplegate and A. C. Fox. "Ecological distribution of pesticides in Lake Poinsett, S. Dakota". Trans. Amer. Fish Soc. 99:496-500, 1970.
- 24 Holden, A. V. and K. M. Marsden. "The examination of surface water and sewage effluents for organo-chlorine pesticides". J. Proc. Inst. Sew. Purif. (G.B.) 1966, pp. 295-299.
- 25 Leshniowsky, W.O., P.R. Dugan, R. M. Pfister, J. I. Frea and C. I. Rondles. Adsorption of Chlorinated Hydrocarbon Pesticides by Microbiol Floc and Lake Sediments and its Ecological Duplications. Inter. Assoc. of Great Lakes Res. Proc. 13th Conference, 1970, pp. 611-618.

- 26 deKoning, H. W. and D. C. Mortimer. "DDT Uptake and Growth of *Emydena gracilis*", Bull. of Environmental Contam. and Toxicol. 6(3):244-248, 1971.
- 27 Yeh, H.H. The Uptake and Persistence of Pesticides in an Algae-laden Environment. Ph.D. Dissertation, V.P.I., 1970.
- 28 Johnson, B.J., C.R. Saunders, H.O. Sanders, and R.S. Campbell. "Biological Magnification and Degradation of DDT and Aldrin by Freshwater invertebrates", J. Fish. Res. Bd. Canada 28: 705-709, 1971.
- 29 Macek, K., C.R. Rodgers, P.L. Stalling and Sidney Korm. "The uptake, distribution and stimulation of dietary ¹⁴C-DDT and ¹⁴C-Dieldrin in Rainbow Trout", Trans. Amer. Fish. Soc. 99(4):689-695, 1970.
- 30 Fromm, P.O. and R. C. Hunter. "Uptake of Dieldrin in isolated perfused gills of rainbow trout", J. Fish. Res. Bd. Canada 26:1939-1942, 1969.
- 31 Nacok, K.J. and S. Korm. "Significance of the food chain in DDT accumulation by fish", J. Fish. Res. Bd. Canada 27: 1496-1498, 1970.
- 32 Menzel, D.N., J. Anderson and A. Randtke. "Marine phytoplankton vary in their response to chlorinated hydrocarbons", Science 167:1724-1726, 1970.
- 33 Wurster, C.F., Jr. "DDT Reduces Photosynthesis by Marine Phytoplankton", Science 159: 1474-1475, 1968.
- 33a Stadnyk, L., R. S. Campbell and B.T. Johnson. "Pesticide Effect on Growth and ¹⁴C-Assimilation in a Freshwater Alga", Bull. Environ. Contam. & Toxicol. 6(1):1-8, 1971.
- 34 Sanders, H.O. and O.B. Cope. "The Relative Toxicities of Several Pesticides to Naiads of Three Species of Stoneflies", Limnol. & Oceanog. 13(1): 112-117, 1968.
- 35 Sanders, H.O. and O.B. Cope. "Toxicities of Several Pesticides to two Species of Cladocerans", Trans. Amer. Fish. Soc. 95(2): 165-169, 1966.

- 36 Thompson, A.R. Stonefly metabolism and the Effects of DDT , Ph.D. Dissertation, University of Utah, 1971.
- 37 Macek, K.J. and W.A. McAllister. "Insecticide Susceptability of Some Common Fish Family Representatives", Trans. Amer. Fish. Soc. 99(1): 20-27, 1970.
- 38 Macek, K.J. and H.O. Sanders. "Biological Variation in the Susceptability of Fish and Aquatic Vertebrates to DDT", Trans. Amer. Fish. Soc. 99(1): 89-90, 1970.
- 39 ----- In Annual Progress Report: 1970, Fish-Pesticide Research Laboratory. Bureau of Sport Fisheries and Wildlife, Columbia, Mo.
- 40 Rodgers, C.A. and D.L. Stalling. In Annual Progress Report: 1970. Fish-Pesticide Research Laboratory. Bureau of Sport Fisheries and Wildlife, Columbia, Mo.
- 41 Mayer, F.L., Jr. In Annual Progress Report: 1970. Fish-Pesticide Research Laboratory. Bureau of Sport Fisheries and Wildlife, Columbia, Mo.
- 43 Rodgers, C.A. "Uptake and Elimination of Simazine by Green Sunfish", Weed Science. 18(1): 134-136, 1970.
- 44 Murphy, P.G. and J.V. Murphy. "Covalation Between Respiration and Direct Uptake of DDT in the Mosquitto Fish", Bull. Environ. Contam. & Toxicol. 6(6): 581-588, 1971.
- 45 Lee, E.L. "Measurement of Pesticide Toxicity by Fish Respiration Rate. Sc.D. Dissertation, Washington University, 1969.
- 46 Greer, G.L. and U. Paim. "Degradation of DDT in Atlantic Salmon", J. Fish. Res. Bd. Canada, 25: 2321-2326, 1968.
- 47 Bardide, G.E., E.J. Harris, H.J. Dean, T.M. Walker, J. Skea and D. Colby. "The Accumulation of DDT in Lake Trout and the Effect on Reproduction", Trans. Amer. Fish. Soc. 93(2): 127-136, 1964.
- 47a Smith, R.M. and C.F. Cole. "Chlorinated Hydrocarbon Insecticide Residues in Winter Flounder", J. Fish. Res. Bd. Canada. 27:2374-2380, 1970.

- 48 Janicki, R.H. and W.B. Kinter. "DDT: Disrupted Osmoregulatory Events in the Intestine of the Eel, Anguilla rostrata, Adapted to Seawater". Science. 173: 1146-1148, 1971.
- 49 Grant, B.F. and P.M. Mehrle. "Chronic Endrin Poisoning in Goldfish". J. Fish. Res. Bd. Canada. 27:2225-2232, 1970.
- 49a Eisler, R. and P.H. Edmunds. "Effects of Endrin on Blood and Tissue Chemistry of a Marine Fish". Trans. Amer. Fish. Soc. 95(2):153-159, 1966.
- 50 Lane, C.E. and E.D. Scura. "Effects of Dieldrin on Glutamic Oxaloacetic Transaminase in Poecilia latipinna". J. Fish. Res. Bd. Canada. 27: 1869-1871, 1970.
- 51 Buhler, D.R. and W.E. Shanks. "Influence of Body Weight on Chronic Oral DDT Toxicity in Coho Salmon". J. Fish. Res. Bd. Canada. 27:347-358, 1970.
- 52 Roelofs, T.D. Effects of Dieldrin on the Intrinsic Rate of Increase of the Guppy. Ph.D. Dissertation, Oregon State University, 1971.
- 53 Anderson, R.B. and W.H. Everhart. "Concentrations of DDT in Landbodied Salmon at Sebago Lake, Maine". Trans. Amer. Fish. Soc. 95(2): 160-164, 1966.
- 54 Poff, R.J. and P.E. Degurse. "Survey of Pesticide Residues in Great Lakes Fish". Wisconsin Department of Natural Resources. Mngt. Rpt. No. 34, 1970.
- 55 -----, Annual Report of Progress: 1970. Fish-Pesticide Research Laboratory. Columbia, Mo.
- 56 Johnson, L.G. Pesticides in the Edible Portion of Fish from Iowa Water. The State Hygienic Laboratory. # 70-33. 1970. Ames, Ia.
- 58 Allison, D., B. Kallman, O.B. Cope, and C.C. Van Valin. "Insecticides: Effects on Cutthroat Trout of Repeated Exposure to DDT". Science. 142:958-961, 1963.
- 59 Atchison, G.J. Lipid and DDT Dynamics in Developing Brook Trout Eggs and Fry. Ph.D. Dissertation. Michigan State University, East Lansing, 1970.

- 60 Mazone, C.R. and B.G. Blaylock. "Toxicity of Insecticide Formulations to Carp Embryos Reared in vitro". Jour. Wildlife Management. 34:460-463, 1970.
- 61 Anderson, J.M. and M.R. Peterson. "DDT: sublethal effects on brook trout nervous system". Science. 164:440-441, 1969.
- 62 Anderson, J.M. "Effect of Sublethal DDT on the Lateral Line of Brook Trout". J. Fish. Res. Bd. Canada. 25: 2677-2682, 1968.
- 62a Anderson, J.M. and H.B. Prins. "Effects of Sublethal DDT on a Simple Reflex in Brook Trout". J. Fish. Res. Bd. Canada. 27: 331-334, 1970.
- 63 Culley, D.D., Jr. and D.E. Ferguson. "Patterns Of Insecticide Resistance in the Mosquitofish, Gambusia affinis". J. Fish. Res. Bd. Canada. 26:2395-2401, 1969.
- 64 Yarbrough, J.D. and M.R. Wells. "Vertebrate Insecticide Resistance: The in vitro Endrin Effect on Succinic Dehydrogenase Activity on Endrin Resistant and Susceptable Mosquitofish". Bull. Environ. Contam. & Toxicol. 6(2): 171-176, 1971.
- 65 Cory, L., P. Fjeld, and W. Serat. "Environmental DDT and the Genetics of Natural Populations". Nature. 229:128-130, 1971.
- 66 Cope, O. B. "Contamination of the Freshwater Ecosystem by Pesticides". J. Appl. Ecol. 3(Supplement): 33-44, 1966.
- 67 Walker, C. R. "Chemicals and Their Effect on the Aquatic Environment". Proc. Southern Weed Science Society. 24: 39-57, 1971.
- 68 Walker, C. R. Problems in Clearance and Registration of Herbicides for Aquatic Areas. U. S. Department of Interior, 1969.
- 69 Sprague, J. B. "Measurement of Pollutant Toxicity to Fish. I. Bioassay Methods for Acute Toxicity". Water Research. 3: 793-821, 1969.

- 70 Sprague, J. B. "Measurement of Pollutant Toxicity to Fish. II. Utilizing and Applying Bioassay Results". Water Research. 4(1): 3-32, 1970.
- 71 Sprague, J. B. "Measurement of Pollutant Toxicity to Fish. III. Sublethal Effects and 'Safe' Concentrations". Water Research. 5(6): 245-266, 1971.
- 72 Post, George and T. R. Schroeder. "The Toxicity of Four Insecticides to Four Salmonid Species". Bull. Environ. Contam. & Toxicol. 6(2): 144-156, 1971.
- 73 Deichmann, W. B. and J. L. Radomski. "Retention of Pesticides in Human Adipose Tissue - Preliminary Report". Industr. Med. & Surg. 37: 218-219, 1968.
- 74 Radomski, J. L., W. B. Deichmann and E. E. Clizen. "Pesticide Concentrations in the Liver. Brain and Adipose Tissue of Terminal Hospital Patients". Fd. Cosmet. Toxicol. 6: 209-220, 1968.
- 75-89 References to be provided under separate cover.
- 90 Cecil, H. C., J. Bitman and S. J. Harris. "Estrogenicity of O,p'-DDT in Rats". Agr. & Food Chem. 19: 61-65, 1971.
- 91 Fahim, M. S., R. Bennett and D. G. Hall. "Effect of DDT on the Nursing Neonate". Nature. 228: 1222-1223, 1970.
- 92 O'Leary, J. A., J. E. Davies, W. F. Edmundson and M. Feldman. "Correlation of Prematurity and DDE Levels in Fetal Whole Blood". Amer. J. Obstet. & Gynecol. 106: 939, 1970.
- 93 O'Leary, J. A., J. E. Davies, W. F. Edmundson and G. A. Reich. "Transplacental Passage of Pesticides". Amer. J. Obstet. & Gynecol. 107: 65-68, 1970.
- 94 Deichmann, W. B. and W. E. MacDonald. "Organo-chlorine Pesticides and Human Health". Fd. Cosmet. Toxicol. 9: 91-103, 1971.

APPENDIX F

DEGRADATION OF PESTICIDES IN THE ENVIRONMENT

State of the Art

In line with the increasing general concern about pesticides, there have been a considerable number of expert committees, panels and conferences which have dealt with all aspects of pesticides, including their fate in the environment after application. Thus, the available information on this topic has been exhaustively reviewed, abstracted and commented upon in the recent past by many of our foremost experts in the field.

Publications emanating from these activities include the "Report of the President's Science Advisory Committee - Use of Pesticides," May 15, 1963; "Scientific Aspects of Pest Control," National Academy of Sciences - National Research Council, 1966 (1); "Report of Committee on Persistent Pesticides," Division of Biology and Agriculture, National Research Council, 1969 (2); "Cleaning our Environment - The Chemical Basis for Action," American Chemical Society, 1969 (3), and, the most comprehensive state of the art summary yet,

the "Report of the Secretary's Commission on Pesticides and their Relationship to Environmental Health," U. S. Department of Health, Education and Welfare, December 1969 (4), more popularly known as the "Mrak Report," after its chairman.

The first and second annual reports of the Council on Environmental Quality to the U. S. Congress (5, 6) also deal with the problems of pesticides.

In addition, many recent meetings of scientific societies have featured symposia, workshops and paper reading sessions dealing with pesticides in the environment, including the American Chemical Society, the Entomological Society of America, different Engineering Societies, and probably many or all of the other learned societies whose scope of interest includes pesticides.

It appears to be the consensus of all of these comprehensive and learned studies and evaluations that

- present levels of pesticide residues in man's food and environment do not adversely affect human health;
- present methods of regulating pesticides provide effective products and generally have held the amounts of residues in man and his food supply at low levels;
- present pesticide use levels cause environ-

mental contamination, adverse effects on certain species of wildlife, and further actual or potential environmental harm whose nature and extent may escape our present capabilities of detection and/or foresight.

The uncertainty about long-term environmental effects, especially of chlorinated hydrocarbons in the marine environment, is strongly emphasized by the Panel on Monitoring Persistent Pesticides in the Marine Environment of the Committee on Oceanography of the National Academy of Sciences in a very recent report (7).

This national concern has been paralleled by similar activities in the midwestern states. For example, Iowa State University held a conference on "The Role of Agriculture in Clean Water" at Ames, Iowa in November, 1969. Willrich and Smith have summarized, edited and published the proceedings of this conference in a 414-page book entitled "Agricultural Practices and Water Quality" (8).

An international symposium on "Pesticides in the Soil: Ecology, Degradation and Movement" was held in February, 1970 at Michigan State University, East Lansing (9).

In both of these publications, each author's contribution is followed by an extensive listing of literature references which in turn include all other appli-

cable review articles and original research reports.

A review of these copious sources of information leads to the conclusion that in effect, very little is known about the fate of pesticides in the environment under actual field conditions. Many investigators have studied individual factors or subsystems under laboratory or greenhouse conditions but, as Kaufman (10, 11) comments:

Unfortunately, the mechanisms observed in model systems are not always the same as those observed in soils. The ultimate question the microbiologists or biochemists must face, therefore, is whether or not the degradative mechanisms observed in vitro are applicable or even relevant to in vivo systems.

Biggar (12), in discussing pesticide movement in soil water, shares this view, stating:

There is considerable literature on field and laboratory investigations on the behavior of a wide range of pesticide compounds for a large number of soils and climatic conditions. Such investigations have provided rough guidelines for the use of these chemicals while knowledge is lacking on the many variables that determine their behavior. Many of these investigations were on leaching and movement. Quite often, leaching studies are used as a means of assessing the adsorptive properties of soils with ranges in texture representing ranges in adsorptive capacity. Generally, very little is known or reported on the important water relations or physical properties, or on factors which are quantitative measures of

the transport process. Likewise, no direct measurements are reported of soil adsorptive capacity. . . . Incomplete studies of transport that do not include variables of flow do not explain transport or predict transport or adsorption. . . . The movement and distribution of a pesticide under limited conditions cannot be projected to a wide range of conditions without quantitative understanding of the factors that contribute to and affect transport. Implicit in this last statement is the necessity for models that will assist in the design of experiments and in extension or prediction of results from observations made.

In those instances where actual field conditions have been investigated, so-called "soil persistence studies" are the most common type of test reported. However, such studies usually measure the "persistence" or "disappearance" of chemicals by analytical methods sensitive only to the parent compound. As Lichtenstein (13) points out, "disappearance" has in most cases been equated simply with the inability to detect the originally applied compound where it had been applied. This often does not account for the metabolism of the parent compound into other chemicals which could also be biologically active. "When we speak of disappearance or loss through volatilization, the parent compound or its metabolites really have not disappeared, except that they have been transported somewhere else."

For the present study, we selected two specific pesticides for more detailed investigation of available data on their fate in the environment, based on the following rationale:

- (1) aldrin: We estimate that more than 10 million pounds of aldrin active ingredient have been used on corn annually in the five state area in recent years (Appendix B, Table 9-B). This use may decline in the future due to development of resistance in some of the insects on which aldrin is used and because of regulatory restrictions and recommendations against its use in some of the states. In spite of these factors, the use of aldrin on corn in the midwest is still surprisingly high. At the same time, aldrin is known to metabolize into dieldrin, a highly persistent and lipophilic chemical which has a strong tendency to accumulate and "biomagnify" in the environment.
- (2) atrazine: We estimate that approximately 30 million pounds of atrazine per year are used on corn in the five state area. Atrazine is not as persistent as the aldrin/dieldrin complex and does not appear to "biomagnify".

However, its residues following a full-rate application often persist in the soil long enough to be phytotoxic to crops other than corn grown on treated land the following season. Thus, atrazine must be considered a moderately persistent chemical. It is of concern for this reason, combined with the large volume in which it is used in the five states.

Aldrin

Aldrin and its main metabolite, dieldrin, which is also an insecticide in its own right, belong to a group of highly chlorinated cyclic hydrocarbons produced by the Diels-Alder diene reaction. Their discovery in the late 1940's is attributed to Julius Hyman (14). Shell Chemical Company is the only manufacturer of both insecticides in the U. S. at present. Both aldrin and dieldrin have been in large scale commercial use for many years. A huge volume of scientific literature deals with these chemicals.

In the five state area, by far the most important use of aldrin is for the control of soil insects on corn. For this purpose, the product is applied directly to the soil by way of granular formulations or, to a much smaller

extent, as a spray or impregnated on fertilizer.

The extensive literature on the fate of aldrin can basically be summarized in one sentence: "The mechanisms by which aldrin and dieldrin are lost from soils are not known for certain" (15). Data indicate that volatilization may be one of the important routes of "disappearance" of aldrin (9, 15, 16, 17, 18, 19). A substantial pathway of aldrin metabolism is its epoxidation to dieldrin (9, 15, 20). Leaching and surface run-off in water as a solute have not been shown to occur with aldrin and are unlikely because of its low water solubility (9, 16, 19). However, aldrin is strongly adsorbed on soil particles and may therefore be transported away from sites of application by soil erosion or wind erosion (9, 15, 16). It has also been shown, although only in the laboratory, that aldrin can be degraded by microbes under aerobic as well as anaerobic conditions (9, 15, 21, 22). Its conversion to dieldrin can also occur non-biologically (9).

Dieldrin is the major known metabolite of aldrin (9, 15, 20). Its vapor pressure is much lower than that of aldrin, and volatilization would therefore occur to a lesser extent as compared to aldrin, except when dieldrin residues are directly exposed on the soil surface (18, 23, 24, 25). Dieldrin can be isomerized, physi-

cally as well as biologically, to "photo-dieldrin", an isomer more toxic than the parent compound to many biological organisms. Dieldrin may also be converted to more polar degradation products. One of these is the diol formed by hydrolysis of the epoxide group; the others are unidentified (9, 15, 26).

As with aldrin, leaching and surface run-off of dieldrin as a solute in water do not occur to any appreciable extent, but adsorption on soil particles and disappearance from site of application by soil erosion or wind erosion may be substantial (9, 15, 16). Dieldrin is much more resistant to microbial degradation than aldrin as demonstrated in laboratory studies. Some soil organisms have been reported to be capable of degrading dieldrin, but it is not known to what extent this may occur in the field (9, 22). The "average half-life" of dieldrin has been reported to be 3-4 years, as opposed to approximately 6 months for aldrin under similar experimental conditions (15).

Thus, dieldrin is considerably more stable than aldrin and therefore reason for greater concern from an environmental standpoint. It is not surprising that along with DDT, dieldrin residues are most ubiquitous in all elements of the environment, especially waterways (27, 28, 29, 30, 31). The aldrin-dieldrin pair

is the only pesticide group whose residues in food, as determined by comprehensive monitoring studies, were so high that the dietary intake exceeded the allowable standards established by the World Health Organization. This occurred in the mid-sixties. Food residues of the aldrin-dieldrin group have since declined somewhat and have remained below the WHO acceptable level up to the present (6, 32, 33).

The midwestern states, especially Iowa and Illinois, have used large quantities of aldrin on their extensive corn acreage for many years. Consequently, dieldrin residues have been found in these states in soils, waterways, crops, poultry, beef, pork, milk and fish. Attempts have been made to track down the origin of dieldrin residues found in certain beef or dairy herds, but this has generally proved to be unexpectedly difficult. One source of dieldrin residues in animals and animal products seems to be direct contamination of feed with pesticide granules (34). A second important source is feed and forage grown on land previously treated with aldrin. Animal husbandmen, especially dairymen, are being advised not to feed any items grown on land which has received aldrin treatments within the last two years. However, in the light of the heavy use of aldrin in these states, this recommendation is not realistic in many instances.

Concerning the presence of aldrin and dieldrin residues in Iowa waters, sediment, and fish (31), there is a debate on whether these originate primarily from runoff from agricultural lands, or from direct contamination of waterways by industrial operations such as pesticide manufacturing and formulating activities, pesticide drum refurbishing, or moth proofing. This debate was unresolved at the time of writing of this report.

Extensive data on the human toxicity of aldrin and dieldrin, including toxicological studies of long-term occupational exposure have recently been summarized and published by Jager (35). Pimentel's very recent, excellent compilation of "Ecological Effects of Pesticides on Non-Target Species" (36) includes sections on aldrin and dieldrin. For both chemicals, a considerable body of data is available on quantities or concentrations which were lethal to different organisms, mostly under laboratory conditions. Practically no information is available on the effects of long-term low-level exposure on species other than laboratory mammals.

Very recent findings suggest that dieldrin at dietary feeding levels as low as 0.5 mg/kg. of body weight may affect the learning behavior of sheep (37, 38, 39, 40, 41). The electroencephalograms of the experimental animals also showed deviations from the norm (39, 42).

Thus, we know disturbingly little about the fate of aldrin and dieldrin in the environment after application, about their pathways of metabolism and degradation, and about their effects on non-target species, especially from long-term low-level exposure such as is likely to occur under actual field conditions. The observations by Van Gelder and colleagues cited in the preceding paragraph are one indication that much more research work in this area is needed.

Atrazine

Atrazine herbicide belongs to a family of s-triazines developed in the laboratories of J. R. Geigy, S.A., Basle, Switzerland in the mid-50's. It is one of the world's major chemical pesticides. We estimate that about 80 to 100 million pounds of atrazine active ingredient are produced annually in the United States alone. By far the most important use of atrazine is for the control of weeds in corn. As indicated in Appendix B of this report, we estimate that about 30 million pounds of atrazine per year are used for this purpose in the five state area. Atrazine is marketed primarily as an 80 percent wettable powder formulation trade-named "Aatrex". It is applied as a suspension in water either pre- or post-emergence, by itself or in combination with other

herbicides. Recommended rates of application range from 2 to 4 pounds of active ingredient per acre, depending on soil conditions, soil organic content, etc.

Recognizing the increasingly difficult problem for many scientists to keep abreast of the rapidly growing volume of literature on important pesticides, the Geigy Company and the University of California co-sponsored an international symposium to bring together all available information on s-triazine-soil interactions. Over 150 scientists attended this symposium at Riverside, California in February of 1969. Sixteen papers were presented covering every aspect of s-triazine-soil interactions. These papers include very comprehensive coverage of the scientific literature on this subject up to 1968 and were published together as Volume 32 of "Residues Reviews", edited by F. A. Gunther (43). This volume is made doubly useful by a comprehensive subject index.

A review of this summary of the state of the art leads to a discomfoting conclusion: While there is a large number of papers dealing with laboratory and greenhouse studies, theories and theoretical models and/or reviews of other, like papers, only very scant information is available on the fate of the s-triazines, including atrazine, under actual field conditions. This

is pointed out very succinctly by Kearney (44).

The persistence of atrazine in soils depends on a number of factors including soil texture, soil fertility, rainfall, soil moisture content, quantity of atrazine applied, tillage practices, temperature, organic matter content, pH, soil microbial activity, and others (43, 45). Physical, biological and chemical factors interact in degrading atrazine after application. The relative importance of each of these types of influences is largely unknown.

One important route of detoxification of atrazine appears to be hydrolysis to hydroxyatrazine (11, 45, 46). Photodecomposition is a physical mechanism by which atrazine has been shown to be detoxified under laboratory conditions. However, most s-triazines absorb energy in a wavelength region considerably below that of natural sunlight. It is therefore doubtful if photodecomposition is of major significance under field conditions, especially where the herbicide is incorporated into the soil (44). Volatilization has been demonstrated in laboratory studies but again, it is not known to what extent it may occur under field conditions (44). Likewise, the importance of microorganisms in the metabolism of atrazine is largely unknown (11, 44). Recent studies indicate that microbial degradation in the field may

less important than was previously assumed (11).

In summary, it is believed that atrazine in soil degrades completely with time, but the pathways are not certain. Some studies have shown that nitrogen from the triazine ring is released and may be utilized by plants. It is assumed that hydrolysis of atrazine to hydroxyatrazine is followed by dealkylation, deamination and ring cleavage.

Atrazine is much more water soluble than aldrin/dieldrin. Accordingly, "disappearance" by leaching or horizontal transport dissolved in water are more likely than with less soluble chemicals. However, Hayes (47) points out that there is a lack of correlation between water solubility and leachability. Different soil types altered the order of leachability within the s-triazine group. Helling (48) points out that based on water solubility alone, only 0.75 inch of rain would totally dissolve 5 pounds of active atrazine per acre. Actual field measurements indicate that atrazine is much less mobile in the soil than would be suggested by these figures.

Further studies on the degradation of atrazine after application have been reported since the 1969 symposium. Soil degradation of atrazine was investigated by Goswami and Green (49) and Zimdahl, et al. (50)

Burnside, et al. (51) reported on the soil persistence of repeated annual applications of atrazine in Nebraska. Pape and Zabik (52) further investigated the photodecomposition of atrazine and other s-triazines. Brown and White (53) studied the interactions of twelve different s-triazines with soil clays of varying mineralogical composition and with bentonite. Hance and Chesters developed a method for extraction from the soil and analysis of hydroxyatrazine (54) and studied the fate of this atrazine metabolite in soil and lake sediment (55). Kaufman and Blake conducted further studies on the degradation of atrazine by soil organisms, especially soil fungi (56).

None of these most recent studies changed the basic conclusions as of 1969, and none of them report any major breakthroughs in the further clarification of the pathways of metabolism and degradation of atrazine in the environment.

Adams and co-workers at the University of Minnesota have reported on the interactions between atrazine and other herbicides (57), and between atrazine and phosphorus and manganese, using the growth and mineral composition of soybeans as an indicator (58, 59). They observed in electron microscope studies that phosphorus "toxicity", atrazine injury and manganese deficiency

produced similar effects in chloroplasts. Atrazine or high phosphorus induced apparent manganese deficiency without, however, appreciably affecting the manganese composition of the plants (60). In a growth chamber study, addition of phosphorus to the soil increased the sensitivity of soybeans to sublethal concentrations of atrazine. Dry matter produced and mineral content of soybeans were affected by atrazine as well as by phosphorus treatments (58).

Espinoza, et al. observed interesting interactions between atrazine, other herbicides and fungicide seed treatments on the growth of soybean seedlings (57). These experiments were conducted to study the effects of atrazine residues left in the soil from the preceding cropping season on susceptible crops when weeds are controlled in those crops by application of another herbicide. The results indicate multi-lateral interactions between these chemicals and the extremely complex soil-plant system. Furthermore, they suggest the possibility that a biologically active agent like atrazine may have similar complex effects on aquatic ecosystems which it may reach by way of leaching or run-off from treated areas, misapplication directly to bodies of water, spillage, etc.

Summary and Conclusions

In line with the increasing concern about pesticides

and their possible impact on the environment, a number of recent conferences, panels and committees have addressed themselves to this problem. A large volume of literature on this subject has been exhaustively reviewed, abstracted and commented upon in the recent past. It is the general consensus of these comprehensive studies and reviews that present pesticide use patterns do not adversely affect human health directly, but that they cause adverse effects on certain species of wildlife, and further actual or potential environmental harm whose nature and extent may escape our present capabilities of detection and/or foresight. Many scientists working in this area are increasingly concerned about possible long-term low-level environmental effects.

Based on their volume of use on midwestern farm crops and on their physical, chemical and biological properties, we selected the insecticide aldrin and the herbicide atrazine for a more extensive review of information on their degradation in the environment.

Table 1-F presents a summary and comparison, probably over-simplified, of the factors affecting the degradation of aldrin, dieldrin (the principal metabolite of aldrin) and atrazine. There are important differences in the physical and chemical properties of these

TABLE 1-F

COMPARISON OF FACTORS AFFECTING THE DEGRADATION OF
ALDRIN, DIELDRIN AND ATRAZINE

Factor	Aldrin	Dieldrin	Atrazine
Volatiliza- tion	substantial	small except when on sur- face	occurs, probably not sub- stantial
Metabolism	epoxidation	not known in detail	not known in detail
-major meta- bolite(s)	dieldrin (15-30%)	"photo-diel- drin", diol- compound	hydroxy- atrazine
Leaching	No	No	Yes
Surface run- off			
-in water	negligible	negligible	Yes; may be sub- stantial
-on solids	may be sub- stantial	may be sub- stantial	Yes
Wind erosion	possible	possible	possible but prob- ably minor
Microbial degradation			
-aerobic	demonstrated in the lab, but not con- firmed in the field	demonstrated in the lab, but not con- firmed in the field	possible but prob- ably minor
-anaerobic			
Non-biological degradation	Yes	Yes	substan- tial
Av. Half-life in soil	1 year	1 year	1 year
Vapor pressure	6×10^{-6} mmHg at 25°C	1.8×10^{-7} mmHg at 25°C	3.0×10^{-7} mmHg at 20°C

TABLE 1-2 (Continued)

Factor	Aldrin	Dieldrin	Atrazine
Lipid solubility	High	High	Low
Water solubility	0.027 ppm at 25°C	0.186 ppm 25°C	33 ppm at 27°C
Stability to hydrolysis			
-alkaline	stable	stable	stable in neutral and slightly alkaline or acid media
-acid	stable with dilute acids	stable with dilute acids	

compounds which in turn influence their persistence, degradation and propensity for environmental damage.

Among pathways of "disappearance" from the site of application, volatilization is one possible escape route of aldrin. It has the highest vapor pressure of the three chemicals in this comparison. Volatilization of atrazine may occur, but it is not believed to be substantial.

The exact pathways of metabolism and degradation and the nature of the ultimate breakdown products are essentially unknown for all these chemicals.

Leaching and surface run-off as a solute in water are not likely in the case of aldrin and dieldrin, but may be substantial in the case of atrazine because of its relatively high water solubility. Adsorption on solids and, consequently, transport by soil erosion or wind erosion are possible routes of escape for all three products.

Microbial degradation has been demonstrated in the laboratory, but not confirmed in the field for aldrin and dieldrin. It is possible but probably minor in the case of atrazine.

Non-biological degradation occurs with all three products, probably to a substantial degree, especially in the case of atrazine.

The "average half-life" information is included in this table merely as an indication of the relative persistence of these chemicals in the soil. This information for aldrin and dieldrin is quoted from Edwards (61) who actually gives numerical values. Following a review of available data, he reported an "average half-life" of 0.51 years for aldrin, 2.4 years for dieldrin. We have not included these numerical values in Table 1-F because we agree with Lichtenstein (13) and others who point out that it is impossible to attribute an absolute life time (or half-life) to any of these chemicals. Observations on persistence expressed as "half-lives" are meaningful only in terms of and under the conditions of the particular study in which they were obtained.

Both aldrin and atrazine have been in large-scale commercial use for many years. Yet, disturbingly little is known about their fate in the environment after application, or about their pathways of metabolism and degradation under field conditions. Information on their effects on non-target species consists largely of data on the amounts of chemical lethal to various test organisms, in the majority of cases obtained under laboratory conditions. There is very little information on possible interactions between these pesticides and/or their metabolites with other chemicals. Practically no-

thing is known about possible effects of long-term low-level residues of these pesticides and/or their metabolites on the environment in general, or on aquatic ecosystems in particular.

Thus, it is obvious that there are glaring gaps in our knowledge of the environmental behavior of these important pesticides. The type of research required to fill these gaps will be complex, and it will be successful only if it is planned and performed by an interdisciplinary approach.

The emphasis must be on studies under actual field conditions. Every effort should be made to encourage interdisciplinary teams to engage in comprehensive research on complete ecosystems. Work on isolated organisms in the laboratory, far removed from field reality, with which the present literature is filled is of relatively limited value unless its significance in regard to field conditions can be clearly assessed.

In this connection, it must be recognized that the more comprehensive, interdisciplinary approach is not liable to produce material suitable for quick publication of simple results. The publishing incentive systems in the academic world may require some adjustments in this regard.

The examples of the triazine symposium (43) con-

ducted by the University of California at Riverside in cooperation with the product's manufacturer, as well as the symposium on "pesticides in the soil" conducted at Michigan State University through Guyer's(9) initiative demonstrate how useful such work conferences can be in pulling together all available data and expert opinions on a complex problem. Prerequisites for success are selection of a sufficiently narrow and well-defined subject, good preparation and execution of the conference, and timely publication of the proceedings, preferable with a good index.

Recommendations

We recommend that a massive, interdisciplinary research effort be mounted to clarify the environmental behavior of major pesticides which are expected to continue in use for the foreseeable future. Information needed includes their fate in the environment after application; routes of metabolism, degradation and disappearance; nature of the ultimate breakdown products; effects of long-term exposure of ecosystems to low-level residues; and interactions with other chemicals in the environment. It will be necessary to establish an order of priority among products to be thoroughly investigated in this fashion.

We recommend that the responsibility to establish such a priority system and to plan, spearhead and oversee the research program itself be assigned to a specific office or committee within the EPA.

We further recommend that actual performance of the research work required should not be limited to tax-supported agencies, but that all possible research capacities should be mobilized including those of industry, independent and non-profit research organizations, etc. By and large, industrial and independent research organizations have more experience and have had more success in the management and performance of truly interdisciplinary research than government or university laboratories. This type of experience is greatly needed in this extremely complex area of environmental research.

LITERATURE REFERENCES

- 1 "Scientific Aspects of Pest Control", Publication 1402, National Academy of Sciences - National Research Council, Washington, D. C., 1966.
- 2 Report of Committee on Persistent Pesticides, Division of Biology and Agriculture, National Research Council to U. S. Department of Agriculture, Washington, D. C., May 1969.
- 3 Cleaning Our Environment - The Chemical Basis For Action, A Report by the Subcommittee on Environmental Improvement, Committee on Chemistry and Public Affairs, American Chemical Society, Washington, D. C., 1969.
- 4 Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, Parts I and II, U. S. Department of Health, Education, and Welfare, December, 1969.
- 5 Environmental Quality, the First Annual Report of the Council on Environmental Quality, Transmitted to the Congress August 1970.
- 6 Environmental Quality, the Second Annual Report of the Council on Environmental Quality, August 1971.
- 7 Chlorinated Hydrocarbons in the Marine Environment, Report by the Panel on Monitoring Persistent Pesticides in the Marine Environment, Committee on Oceanography, National Academy of Sciences, Washington, D. C., 1971.
- 8 Willrich, T. L. and G. E. Smith (eds.), Agricultural Practices and Water Quality, The Iowa State University Press, Ames, Iowa, 1970.
- 9 "Pesticides in the Soil: Ecology, Degradation & Movement", International Symposium, Michigan State University, East Lansing, 1970.
- 10 Kaufman, D. D., "Pesticide Metabolism", International Symposium on Pesticides in the Soil, Michigan State University, East Lansing, 1970, pp. 73-85.

- 11 Kaufman, D. D., and P. C. Kearney, "Microbial Degradation of S-triazine Herbicides", Residue Reviews, Vol. 32, 1970, pp. 235-266.
- 12 Biggar, J. W., "Pesticide Movement in Soil Water", International Symposium on Pesticides in the Soil, Michigan State University, East Lansing, 1970, pp. 107-119.
- 13 Lichtenstein, E. P., "Fate and Movement of Insecticides in and from Soils", International Symposium on Pesticides in the Soil, Michigan State University, East Lansing, 1970, pp. 101-106.
- 14 Metcalf, R. L., Organic Insecticides, Their Chemistry and Mode of Action, Interscience Publishers, Inc., New York, London, 1955.
- 15 Aldrin and Dieldrin - A Summary of Literature Relating to Characteristics, Behavior, Occurrence, and Significance of Residue Levels in the Environment, Shell Chemical Company, New York, New York, May 1970.
- 16 Caro, J. H., and A. W. Taylor, "Pathways of Loss of Dieldrin from Soils Under Field Conditions", Agricultural and Food Chemistry, Vol. 19, No. 2, 1971, pp. 379-384.
- 17 Lichtenstein, E. P., and K. R. Schulz, "Volatilization of Insecticides from Various Substrates", Agricultural and Food Chemistry, Vol. 18, No. 5, 1970, pp. 814-818.
- 18 Lichtenstein, E. P., J. P. Anderson, T. W. Fuhremann, and K. R. Schulz, "Aldrin and Dieldrin: Loss under Sterile Conditions", Science, Vol. 159, 1968, pp. 1110-1111.
- 19 Shell Chemical Company/Agricultural Division, Technical Data Bulletin, Summary of Basic Data for Technical Aldrin, ACD: 67-104 (Rev. 9-68).
- 20 Lichtenstein, E. P., T. W. Fuhremann, and K. R. Schulz, "Persistence and Vertical Distribution of DDT, Lindane, and Aldrin Residues, 10 and 15 Years After a Single Soil Application", Agricultural and Food Chemistry, Vol. 19, No. 4, 1971, pp. 718-721.

- 21 Patil, K. E., F. Matsumura, and G. M. Boush, "Degradation of Endrin, Aldrin, and DDT by Soil Microorganisms", Applied Microbiology, Vol. 19, No. 5, 1970, pp. 879-881.
- 22 Matsumura, F., and G. M. Boush, "Metabolism on Insecticides by Microorganism", Soil Biochemistry, Marcel Dekker, New York, Vol. 2, 1971, pp. 320-336.
- 23 Spencer, W. F., and M. M. Cliath, "Vapor Density of Dieldrin", Environmental Science & Technology, Vol. 3, 1969, pp. 670-674.
- 24 Spencer, W. F., M. M. Cliath, and W. J. Farmer, "Vapor Density of Soil-Applied Dieldrin as Related to Soil-Water Content, Temperature, and Dieldrin Concentration", Soil Science Society of American Proceedings, Vol. 33, No. 4, 1969, pp. 509-511.
- 25 "Summary of Basic Data for Technical Aldrin", Shell Chemical/Agricultural Division, Technical Data Bulletin, ACD: 67-105 (Rev. 2-71).
- 26 Matsumura, F., K. C. Patil, and G. M. Boush, "Formation of 'Photodieldrin' by Microorganisms", Science, Vol. 170, 1970, pp. 1206-1207.
- 27 Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., 1968.
- 28 Wiersma, G. B., P. F. Sand, and R. L. Schutzmann, "National Soils Monitoring Program - Six States, 1967", Pesticides Monitoring Journal, Vol. 5, No. 2, 1971, pp. 223-227.
- 29 Henderson, C., A. Inglis, and W. L. Johnson, "Organochlorine Insecticide Residues in Fish - Fall 1969 National Pesticide Monitoring Program", Pesticides Monitoring Journal, Vol. 5, No. 1, 1971, pp. 1-11.
- 30 Lichtenberg, J. J., J. W. Eichelberger, R. C. Dressman, and J. E. Longbottom, "Pesticides in Surface Waters of the United States - A 5-Year Summary, 1964-68", Pesticides Monitoring Journal, Vol. 4, No. 2, 1970, pp. 71-86.

- 31 Johnson, L. G., and R. L. Morris, "Chlorinated Hydrocarbon Pesticides in Iowa Rivers", Pesticides Monitoring Journal, Vol. 4, No. 4, 1971, pp. 216-219.
- 32 Duggan, R. E., G. Q. Lipscomb, E. L. Cox, R. E. Heatwole, and R. C. Kling, "Pesticide Residue Levels in Food in the United States from July 1, 1963 to June 30, 1969", Pesticides Monitoring Journal, Vol. 5, No. 2, 1971, pp. 73-212.
- 33 Corneiliussen, P. E., "Pesticide Residues in Total Diet Samples (V)", Pesticides Monitoring Journal, Vol. 4, No. 3, 1970, pp. 89-92.
- 34 Buck, W. B., and W. Van Note, "Aldrin Poisoning Resulting in Dieldrin Residues in Meat and Milk", Journal of the American Veterinary Medical Association, Vol. 153, No. 11, 1968, pp. 1472-1475.
- 35 Jager, K. W., Aldrin, Dieldrin, Endrin & Telodrin, Elsevier Publishing Company, Amsterdam/London/New York, 1970.
- 36 Pimentel, D., Ecological Effects of Pesticides on Non-Target Species, Executive Office of the President, Office of Science and Technology, Washington, D. C., 1971.
- 37 Sandler, B. E., G. A. Van Gelder, W. B. Buck, and G. G. Karas, "Effect of Dieldrin Exposure on Detour Behavior in Sheep", Psychological Reports, 1968, 23, pp. 451-455.
- 38 Van Gelder, G. A., B. E. Sandler, W. B. Buck, and G. G. Karas, "Convulsive Seizures in Dieldrin Exposed Sheep During Photic Stimulation", Psychological Reports, 1969, 24, p. 502.
- 39 Van Gelder, G. A., B. E. Sandler, W. B. Buck, J. B. Maland, G. G. Karas, "Behavioral and Electrophysiological Effects of Dieldrin in Sheep", Industrial Medicine, Vol. 38, No. 3, 1969, pp. 64-67
- 40 Sandler, B. E., G. A. Van Gelder, D. D. Elsberry, G. G. Karas, and W. B. Buck, "Dieldrin Exposure and Vigilance Behavior in Sheep", Psychon. Science, Vol. 15 (5), 1969, pp. 261-262.

- 41 Van Gelder, G. A., Dieldrin Induced Behavioral Decrement in Sheep, Manuscript in Preparation.
- 42 _____, W. B. Buck, R. Sandler, J. Maland, and G. Karas, "The Effects of Dieldrin and Ruelene Exposure on Experimental Behavior and the Electroencephalogram", Environmental Health Sciences Series, No. 1, pp. 125-133.
- 43 Gunther, F. A. (ed.), "The Triazine Herbicides", Residue Reviews, Volume 32, Springer-Verlag, New York/Heidelberg/Berlin, 1970.
- 44 Kearney, P. C., "Summary and Conclusions", Residue Reviews, Vol. 32, 1970, pp. 391-399.
- 45 Aatrex Herbicide, Technical Bulletin, Geigy Agricultural Chemicals, Division of Ciba-Geigy Corporation, Ardsley, New York, May, 1971.
- 46 Jordan, L. S., W. J. Farmer, J. R. Goodin, and B. E. Day, "Non-biological Detoxication of the s-Triazine Herbicides", Residue Reviews, Vol. 32, 1970, pp. 267-286.
- 47 Hayes, M. H.B., "Adsorption of Triazine Herbicides on Soil Organic Matter, Including a Short Review on Soil Organic Matter Chemistry", Residue Reviews, Vol. 32, 1970, pp. 131-174.
- 48 Helling, C. S., "Movement of a-Triazine Herbicides in Soils", Residue Reviews, Vol. 32, 1970, pp. 175-210.
- 49 Goswami, K. P. and R. E. Green, "Microbial Degradation of the Herbicide Atrazine and its 2-Hydroxy Analog in Submerged Soils", Environmental Science & Technology, Vol. 5, No. 5, 1971, pp. 426-429.
50. Zimdahl, R. L., V. H. Freed, M. L. Montgomery, and W. R. Furtick, "The Degradation of Triazine and Uracil Herbicides in Oil", Weed Research, 10, 1970, pp. 18-26.
- 51 Burnside, O. C., C. R. Fenster, and G. A. Wicks, "Soil Persistence of Repeated Annual Applications of Atrazine", Weed Science, Vol. 19, No. 3, 1971, pp. 290-293.

- 52 Pape, B. E., and M. J. Zabik, "Photochemistry of Selected 2-Chloro and 2-Methylthio-4,6-di-(Alkylamino)-S-Triazine Herbicides", Journal of Agricultural and Food Chemistry, Vol. 18, No. 2, 1970, pp. 202-207.
- 53 Brown, C. B. and J. L. White, "Reactions of 12 s-Triazines with Soil Clays", Soil Science Society of America Proceedings, Vol. 33, No. 6, 1969, pp. 863-867.
- 54 Hance, R. J., and G. Chesters, "Extraction of Hydroxyatrazine from Soil", Analyst, Vol. 95, 1970, p. 106.
- 55 _____, "The Fate of Hydroxyatrazine in a Soil and a Lake Sediment", Soil Biological Biochemistry, Vol. 1, 1969, pp. 309-315.
- 56 Kaufman, D. D., and J. Blake, "Degradation of Atrazine by Soil Fungi", Soil Biological Biochemistry, Vol. 2, 1970, pp. 73-80.
- 57 Espinoza, W. G., R. S. Adams, Jr., and R. Behrens, "Interaction Effects of Atrazine and CDDA, Linuron, Amiben, or Trifluralin on Soybean Growth", Agronomy Journal, Vol. 60, 1968, pp. 183-185.
- 58 Adams, R. S., and W. G. Espinoza, "Effect of Phosphorus and Atrazine on Mineral Composition of Soybeans", Agricultural and Food Chemistry, Vol. 17, No. 4, 1969, pp. 818-822.
- 59 Sun, C. N., and R. S. Adams, Jr., "Effects of the Phosphorus-Manganese-Atrazine Interaction in Soybean Plants", Agricultural and Food Chemistry, Vol. 19, No. 2, 1971, pp. 325-330.
- 60 Adams, Jr., R. S., C. N. Sun, "Physiological and Metabolic Effects of Trace Substances on Plants and the Implication of Man", Trace Substances in Environmental Health - IV, University of Missouri, 1971, pp. 307-317.
- 61 Edwards, C. A., "Soil and Fertilizers", 27, 1964, p. 451 (quoted from 15, p. 3).
- 62 Weber, J. B., "Mechanisms of Adsorption of s-Triazines by Clay Colloids and Factors Affecting Plant Availability", Residue Reviews, Vol. 32, pp. 93-130.

APPENDIX G

ALTERNATIVES TO CHEMICAL CONTROL OF WEEDS AND INSECTS

An understanding of the most important weed, insect and disease problems in the study area is essential to an evaluation of possible alternatives to chemical control. This topic is therefore presented in this section rather than in Appendix B of this report.

Weeds

Table 1-G summarizes the most important weeds affecting field crops, especially corn, soybeans and small grains, in the five state area as reported by weed scientists in each state. It will be noted that by and large, these weed complexes are very similar throughout the five state area, with only relatively minor variations.

In most states, mention was made of *Panicum* species as being on the increase. It was also reported that perennial weeds are slowly becoming more prevalent, probably because the annual weeds are so effectively controlled by chemical herbicides. Wild cane (*Sorghum bicolor*), a relative of grain sorghum, is changing from a mere curiosity ten to twenty years ago to a problem of

TABLE 1-G
SUMMARY OF MAJOR WEEDS AFFECTING FIELD CROPS IN THE 5 STATE AREA

State	Minnesota	Iowa	Illinois	Missouri	Kansas
Annual Weeds	foxtails pigweed lambsquarter smartweed ragweed barnyard grass crabgrass Panicum velvetweed wild sunflower cocklebur wild oats	giant foxtail barnyard grass smartweed velvetweed wild sunflower cocklebur	giant foxtail pigweed smartweed lambsquarter velvetweed pigweed jimsonweed cocklebur Panicum	giant foxtail crabgrass Panicum barnyard grass jimsonweed pigweed lambsquarter cocklebur velvetweed smartweed ragweed	giant foxtail other foxtails pigweed wild cane Panicum velvetweed cocklebur
Perennial Weeds	quackgrass Canada thistle nutsedge field bindweed	Canada thistle milkweed	johnsongrass nutsedge Canada thistle quackgrass milkweed	johnsongrass nutsedge	field bindweed bur ragweed

major economic importance in corn and grain sorghum, especially in Kansas. The weed thrives on the growing conditions most favorable to the crop and therefore cannot be controlled by cultural practices. Wild cane can be controlled chemically in corn, but there is no herbicide sufficiently selective to control it in grain sorghum.

In Minnesota, it was feared that the increasing use of the newly developed semi-dwarf varieties of wheat will result in greater weed problems in the future because they are less aggressive than presently grown wheat varieties.

Alternatives to Chemical Weed Control

Chemical herbicides have generally not caused as much concern in regard to actual or potential environmental damage as insecticides. Consequently, less attention and effort has been devoted to the development of non-chemical weed control methods.

Weed control at the farm level has by and large never relied exclusively or even predominantly on the use of chemicals, but has always been a "pest management" or "integrated control" system, long before these particular terms became fashionable. This is especially true of the key midwestern farm crops, corn, soybeans and small grains. Long before the present highly

effective chemical herbicides became available, many farming practices such as crop rotation, tillage, selection of planting date, cultivating, etc. were used intentionally to suppress weeds and to influence the competition between crops and weeds for light, nutrients and water in favor of the crops. These practices were not abandoned when chemical herbicides became known, but these new tools were truly integrated into the existing agricultural practices.

We discussed this situation with 214 farm agents from the five state area. They indicated that cultivation for weed control and rotation primarily for corn rootworm are practiced although as labor, costs and materials increase these techniques are losing favor. It is pointed out that local weather conditions may prevent adequate cultivation and the farmers thus resort to chemical treatment.

It is interesting to note in this connection that in the U. S. Department of Agriculture's Agricultural Research Service as well as in most state universities and extension services, weed scientists and specialists usually are members of Agronomy, Botany or Plant Physiology departments or agencies. Perhaps this has contributed to the fact that weed control appears to be researched and practiced much more by an interdisciplinary

"systems approach" than the control of insects. Entomology is usually organized in separate departments at the universities, and there is a separate "Entomology Research Division" within the USDA.

Biological agents to control weeds have been successfully employed in at least two instances, i.e., against the prickly pear in Australia, and against the Klamath weed in the western United States. Very little work along these lines has been done on the weed complex in the five state area, and the scientists interviewed were generally not optimistic about this approach in this part of the country. At least one actual lead which was considered proved unsuccessful. A lepidopterous species affects Canada thistle once every few years and then reduces this perennial weed significantly. However, once the insect population builds up to the extent that the thistle supply gets low, the "beneficial" insects begin to feed on soybeans and other crops.

One of the elements important to good "integrated control" practices is information on economic damage thresholds. This subject has received considerable attention by several groups of scientists in the five state area, including Staniforth and co-workers (1, 2, 3, 4, 5, 6, 7, 8, 9). These workers studied the competitive effects of major weed species in Iowa on soybeans and corn.

Similar studies have been carried out by Feltner and his colleagues in Kansas (10, 11, 12) on the effects of major Kansas weeds on grain sorghum.

Insects

Table 2-G summarizes key insect pests affecting field crops, primarily corn, in the five state area. The most important insects are the soil insects affecting corn, i.e., corn rootworms and the so-called "soil insect complex."

There are three species of the corn rootworm in the area, i.e., Diabrotica longicornis, the northern corn rootworm; D. virgifera, the western corn rootworm; and D. undecimpunctata howardi, the southern corn rootworm. The northern and the western species are highly resistant to some organic phosphate insecticides. The northern and western species predominate in Minnesota and Iowa. All three species are reported in Illinois, Missouri and Kansas. The southern species is the least damaging one.

The "soil insect complex" includes white grubs, wireworms, webworms, corn billbugs, cutworms and others. Seed-corn maggot and seed-corn beetle are sometimes also included in this complex.

Foliar insects attacking corn include the European corn borer, the southwestern corn borer, corn earworms

TABLE 2-G
SUMMARY OF MAJOR INSECTS AFFECTING FIELD CROPS
IN THE FIVE STATE AREA

State	Minnesota	Iowa	Illinois	Missouri	Kansas
Corn	corn rootworms	corn rootworms	corn rootworms	soil insect complex	corn rootworms
soil insects	soil insect complex ¹	soil insect complex	soil insect complex	corn rootworm	soil insect complex
foliar insects	corn borers	corn borers	corn borers corn earworm	corn borers corn earworm full armyworm	corn rootworm adults fall armyworm corn borers
Wheat foliar insects					greenbugs cutworms
Sorghum foliar insects					greenbugs armyworms webworms

¹Includes white grubs; wireworms; webworms; billbugs; cutworms; seed-corn maggots; seed-corn beetles.

and, in Missouri and Kansas, fall armyworms and corn rootworm adults (especially in Kansas).

Soybeans in the five states are not presently affected by major insect pests requiring routine insecticide treatment. The same is true of small grains with the exception of Kansas, where greenbugs are becoming increasingly damaging on wheat and sorghum. Cutworms on wheat and armyworms and webworms on sorghum also are sufficiently severe in Kansas to require insecticide treatments.

Missouri, Illinois and Kansas anticipated that the increasing intensification of soybean growing practices will bring about greater insect problems on this crop in the future.

Alternatives to Chemical Insect Control

Chemical insecticides have caused far greater concern than other pesticides in regard to the actual and potential environmental damage which they may cause. Consequently, most of the international as well as the United States' efforts in the area of searching for alternate methods of pest control have focused on insect control. This subject has been thoroughly discussed and reviewed at a number of recent conferences, including a symposium on scientific aspects of pest control arranged

and conducted by the National Academy of Sciences, National Research Council at Washington, D. C. in 1966 (13), a working conference on "Insect-Plant Interactions" sponsored by the National Academy of Sciences, held at the University of California at Santa Barbara in 1968 (14); a symposium on potentials in crop protection held at the dedication of a new entomology-plant pathology laboratory at the New York State Agricultural Experiment Station, Geneva, New York, in 1969 (15); and a conference on concepts of pest management, co-sponsored by North Carolina State University, the Entomological Society of America, the Rockefeller Foundation and the National Science Foundation, held at North Carolina State University at Raleigh in 1970 (15).

Furthermore, a committee of the Agricultural Board of the National Research Council, National Academy of Sciences prepared and published an excellent summary on the scientific principles of insect-pest management and control (17).

This extensive literature contains a wealth of basic thoughts, generalities, theories, and principles, while there is a great scarcity of practical case histories of insect management systems, of information on how to actually develop such programs in the field, and of other down-to-earth specifics. Problems such as, for

example, organizational requirements for initiating effective programs, pest control advising systems, etc. have received surprisingly little coverage.

There are no leads in this literature to specific non-chemical methods of control of any of the major insect problems in the five state area. However, we discussed this subject extensively with entomologists inside and outside of the midwest and present below some of the facts and suggestions which emanated from these discussions.

Soil insects in general have received little, if any, attention thus far in regard to the development of microbial, virus, or hormonal agents which might control them selectively. Soil insects are more difficult experimental objects to work with than most other insects. Furthermore, the soil medium itself presents a formidable obstacle to the success chances of such agents which are often not very stable, may have to be ingested orally by the target insect in order to be effective, or are otherwise fragile. Likewise, we have not discovered any evidence of work on attractants, repellents, parasites or predators specific to corn rootworms or other soil insects affecting corn.

Development of various resistant or more tolerant to the effects of insect pests appears to be a more promising approach so far as midwestern field crops

are concerned. Much success has already been achieved in this regard in the development of corn hybrids resistant to the European corn borer.

There is also optimism about the development of corn varieties more resistant to corn rootworms. This "resistance" will probably be in the form of greater tolerance of the plant to the effects of corn rootworm feeding, specifically greater regenerative powers of the corn root system. Another lead which is being pursued is the observation that some corn silks may adversely affect the fecundity and longevity of corn rootworm adults.

However, improved corn varieties with these desirable corn rootworm resistance features are not presently available, and these insects can and do cause severe yield losses to presently available corn varieties.

Corn rootworms are most bothersome in "continuous corn," i.e., when corn is followed by corn in the same field. Crop rotation would break the insects' life cycle and largely eliminate the need for treatment. For instance, when corn is grown following soybeans, insecticide treatments are often not needed at all. However, soybeans cannot be raised successfully on all corn fields, and there are no economically attractive crops other than corn for some growers. Thus, the large scale

use of chemical insecticides for the control of corn rootworms in continuous corn will probably go on at least until the more tolerant varieties of corn become available.

Farm agents felt that of the few cases of attempts at biological control, most were failures. Some local areas reported limited success with ladybugs for aphid control and parasites to control alfalfa weevil. Part of the reported failure of biological methods may be the lack of familiarity with techniques, the unavailability of materials or indifference to trying something new.

County agents should and probably do reflect the current attitude of state colleges of agriculture regarding biological control methods. Most of the agents tended to scoff at the prospects for really satisfactory controls using non-chemical methods.

Until real success is demonstrated by state and other agricultural agencies at the local level, it is doubtful whether biological control methods will gain much in popularity.

Fortunately from an environmental standpoint, increasing corn rootworm resistance has led to progressive replacement of chlorinated hydrocarbon insecticides by organic phosphates and carbamates. These latter chemicals

are generally more toxic to mammals including man, but they are less stable, degrade more rapidly in the environment, and do not biomagnify. Thus, they may be less harmful from an environmental standpoint and pose less of a problem in regard to potential contamination of the aquatic environment.

The "soil insect complex" described above and in Table 2 is most apt to cause damage to corn grown after sod, pasture, forage crops, etc. Chlorinated hydrocarbon insecticides are still used heavily against this complex and against seed-corn maggots and seed-corn beetles.

Entomologists wishing to conduct performance trials against this problem find it most difficult to come up with good results because these insects occur very erratically and infrequently, and almost never affect a field uniformly. If, when and where corn may be damaged by these soil insects is quite unpredictable. Entomologists generally agree, and their difficulties in conducting meaningful field performance trials against these insects confirm, that large quantities of insecticides applied for the control of this soil insect complex, probably as much as 90 percent, are applied needlessly. This is especially deplorable because chlorinated hydrocarbons are the insecticides of choice.

Thus, this is an insecticide use in which the cost/benefit equation is particularly disadvantageous for the environment.

Since specific alternate methods of control for this corn soil insect complex do not appear to be in sight, other options to cope with this problem should be explored. For instance, if an incentive (positive or negative) would be supplied to growers to leave certain fields or parts of fields untreated, more information could be gained about the extent to which the present routine prophylactic insecticide treatments are actually needed. At the same time, this would reduce the total quantity of chemicals applied.

Another possibility would be a general reduction of the amount of insecticide applied per acre and of the number of acres receiving treatment. Illinois in 1971 (18) recommends against the use of aldrin and heptachlor as soil insecticides on corn, citing several interesting reasons. They point out that soil residues of aldrin-dieldrin or heptachlor - heptachlor epoxide from previous applications probably are so high in about 5 million acres of corn fields in the state that soil pests susceptible to these insecticides should be depressed to the extent that further treatments are not required. They also emphasize that perhaps a few

hundred thousand acres of corn would warrant broadcast aldrin or heptachlor treatment against cutworms, but that these fields cannot be selected before the insects actually appear. Therefore, control measures should only be applied where and when insects appear, rather than subjecting millions of acres to insecticide treatments needlessly. These are very sound and timely recommendations. It will be very interesting to see whether or not they have been followed this year. If so, a major reduction in the quantities of chlorinated hydrocarbon insecticides used in Illinois should be apparent in the pesticide use statistics which the state will publish in 1972.

Still another possibility might be establishment of an insurance system similar to hail insurance, coupled with a general ban on preventive use of chlorinated hydrocarbons against soil insects on corn. Growers who would actually suffer demonstrable economic damage from not treating would be reimbursed through the insurance fund. This possibility suggests itself because of obvious parallels between the unpredictability of corn soil insect damage and the similar unpredictability of hail damage.

Finally, crop rotation would also be an effective control tool, but again, as in the case of corn root-

rootworms, this is not economically attractive to many growers under present economic conditions. The consensus of farmers and agents contacted was that ones profit margin was keyed to the use of herbicides.

Diseases

Major field crops in the five state area are not affected by any major plant disease organisms requiring chemical treatment. The disease which received the greatest attention and publicity this past year of course was the southern corn leaf blight. It was observed very closely, but did not become a problem of economic consequence anywhere in the five state area. No significant amounts of fungicides were used against the corn leaf blight in the area in 1970 and 1971. It was pointed out by plant pathologists, however, that the southern corn leaf blight or other corn diseases could very well become major problems in the future because all present corn hybrids are based on only six inbred lines. This is an exceedingly narrow genetic base for a crop covering so many millions of acres in the United States.

It was also pointed out that soybeans are similarly subject to potential large scale disease outbreaks because of an insufficient genetic resistance base. Root rots, stem rots and bacterial diseases are potential major threats to soybeans.

Some of the states expressed concern about the can-

cellation of the registration of mercurial fungicides for seed treatment, especially for small grains, and feared increased incidence of seed and seedling diseases. Plant pathologists in other states applauded the ban of the mercurials and stated that in their opinion, there are effective replacement seed treatments available.

Summary and Conclusions

Field crops in the five state area are affected by a considerable company of weeds, predominantly annual species. However, perennial weeds are slowly becoming more prevalent since the annual weeds are so effectively controlled by chemical herbicides.

There are no specific non-chemical agents such as "beneficial insects" available for control of any of the weeds in this region, and no significant work in this direction appears to be in progress. However, it is noted that weed control at the farm level does not rely exclusively on the use of chemicals, but has always been carried out by the integrated use of many farming practices such as crop rotation, tillage, selection of planting date, etc. This system was not abandoned when chemical herbicides arrived, but these products were included in it.

One of the elements important to good "integrated

control" practices is information on economic damage thresholds. Considerable attention has been devoted to this question by scientists in the area, and their work has provided useful data on the relationships between weed infestations and yields of the major field crops.

By far the most important insect problem in the five states are corn rootworms and soil insects on corn. Much effort has been focused on the search for alternate methods of insect control in general, but soil insects have not received much attention in this regard thus far. To the best of our knowledge, there are no realistic prospects that microbial, hormonal or other agents for selective control of soil insects will be available in the foreseeable future.

All three economically important species of the corn rootworm occur in the five state area. The northern and western species are highly resistant to chlorinated hydrocarbon insecticides and increasingly resistant to some organic phosphate insecticides. Corn rootworms are most damaging in "continuous corn", i.e., when corn is grown without rotation with other crops. The development of corn varieties more tolerant to the effects of corn rootworm feeding is the most promising lead as an alternative to the use of chemicals. However, improved varieties with these desirable corn rootworm resistance

features are not yet available. Crop rotation to break the insects' life cycle is a presently available alternative, but it is not economically attractive to many corn growers.

In the past, the European corn borer caused major damage to corn in the midwest. DDT was used extensively to control it. Much success has been achieved in the development of corn hybrids resistant to this insect.

The "soil insect complex" which includes white grubs, wireworms, sod webworms, corn billbugs, cutworms, seed-corn maggots and seed-corn beetles is most damaging to corn grown after sod, pasture, forage crops, etc. Chlorinated hydrocarbon insecticides still are used heavily against this complex. There are no practical leads to specific non-chemical methods or agents for the control of these insects. At the same time, they occur so erratically and infrequently that entomologists experience great difficulty in conducting meaningful performance trials against them. Many entomologists agree that a large portion of the insecticides applied for this purpose, probably as much as 90 percent, is applied needlessly. Discontinuation of this practice would eliminate a major source of environmental contamination in this area. Several suggestions on how this might be accomplished are discussed above and summarized

in the "Recommendations" section of this chapter.

Soybeans in the five states are not presently affected by major insect pests requiring routine insecticide treatment. However, entomologists anticipate that the increasing intensification of soybean growing practices will bring about greater insect problems on this crop in the future. This situation where a major crop is not yet subject to routine insecticide applications presents a unique challenge and opportunity for the development of suitable "pest management" systems from the outset. In this area, there is a great need for practical, down-to-earth approaches, including development of insect damage threshold data, insect damage forecasting, improved weather forecasting, and establishment of the organizational requirements and structures necessary for effective programs.

Furthermore, in order to use chemical insecticides to best advantage as one element in an integrated system, information is needed on the spectrum of selectivity and the degree of effectiveness of potentially useful products at the low end of their dosage range. The use of presently available insecticides at lower dosage rates is one reservoir of selectivity which is still largely under-utilized, if not completely untapped today.

Recommendations

We recommend that a concerted effort be undertaken to reduce or eliminate the prophylactic use of insecticides, especially chlorinated hydrocarbons, for the control of the "soil insect complex" on corn. Growers should be strongly encouraged to leave entire fields or portions thereof untreated and/or to use insecticides at reduced rates, to establish to what extent, if any, prophylactic insecticide treatments are needed for this purpose. As an alternative or additive measure, establishment of an insurance system similar to hail insurance, coupled with a ban on the prophylactic use of chlorinated hydrocarbon insecticides, should be investigated.

We recommend that the development of a practical, realistic "pest management" system for soybeans receive all necessary research, administrative and organizational attention. The present state of affairs where this important crop is not yet subject to routine insecticide treatments offers a unique opportunity to develop all aspects of a sound insect management system for the bottom up, unincumbered by pre-existing pesticide use patterns, vested interests, etc.

LITERATURE REFERENCES

- 1 Staniforth, D. W., "Competitive Effects of Three Foxtail Species on Soybeans", Weeds, Vol. 13, No. 3, 1965, pp. 191-193.
- 2 _____, and W. G. Lovely, "Preemergence Herbicides in Corn Production", Weeds, Vol. 12, No. 2, 1964, pp. 131-133.
- 3 _____, and C. R. Weber, "Role of Herbicides in Soybean Production", Weeds, Vol. 11, No. 2, 1963, pp. 96-98.
- 4 Staniforth, D. W., "Responses of Soybean Varieties to Weed Competition", Agronomy Journal, Vol. 54, 1962, pp. 11-13.
- 5 Nieto, H. J., and D. W. Staniforth, "Corn-Foxtail Competition Under Various Production Conditions", Agronomy Journal, Vol. 53, 1961, pp. 1-5.
- 6 Staniforth, D. W., "Responses of Corn Hybrids to Yellow Foxtail Competition", Weeds, Vol. 9, No. 1, 1961, pp. 132-136.
- 7 _____, "Soybean-Foxtail Competition Under Varying Soil Moisture Conditions", Agronomy Journal, Vol. 50, 1958, pp. 13-15.
- 8 _____, "Effects of Annual Grass Weeds on the Yield of Corn", Agronomy Journal, Vol. 49, 1957, pp. 551-554.
- 9 Weber, C. R., and D. W. Staniforth, "Competitive Relationships in Variable Weed and Soybean Stands", Agronomy Journal, Vol. 49, 1957, pp. 440-444.
- 10 Feltner, K. C., H. R. Hurst, and L. E. Anderson, "Tall Waterhemp Competition in Grain Sorghum", Weed Science, Vol. 17, No. 2, 1969, pp. 214-216.
- 11 _____, "Yellow Foxtail Competition in Grain Sorghum", Weed Science, Vol. 17, No. 2, 1969, pp. 211-213.

- 12 Vesecky, J. F., Grain Sorghum Responses to Various Densities of Forage Sorghum and Wild Cane , Dissertation, Department of Agronomy, Kansas State University, Manhattan, Kansas, 1972 (in press.)

APPENDIX H

REGULATIONS AND LAWS

Introduction

The implementation of laws adequate to protect the public health is regarded as a normal function of all levels of government. An assessment of the quality of existing laws and the means of implementing them presents a bewildering and complex picture to the professional and lay person alike. The contractor has endeavored to examine and present in concise form, the status of federal and state laws directly pertinent to the five-state study area. By collecting and analyzing pertinent laws and through a series of interviews with key people, a picture of good and bad has been assembled; each will be presented with the contractor's evaluation of areas of needed reform.

Included in this section will be such items as key past events; an appraisal of conflicting interests regarding pesticides, where they exist; trends in pesticide legislation; effectiveness of present laws and a comparison between the study states; and, the contractor's summary and recommendations of needed legislation.

Of particular importance to this study is an analysis of federal laws governing testing and registration of new pesticides and pesticide formulations.

Federal Organization for Pesticide Control

Federal functions for control of pesticide use are vested primarily in the Environmental Protection Agency, being transferred there with the establishment of EPA in December, 1970. Those functions include: (1) the responsibilities (and staff) of the Department of Agriculture under FIFRA for pesticides label registration, (2) the responsibilities of the Food and Drug Administration for pesticides research and standards setting, and (3) certain pesticide research functions carried out by the Bureau of Sports, Fisheries and Wildlife of the Department of Interior. Within EPA, there is an Office of Pesticide Programs under a Deputy Assistant Administrator who reports to the Assistant Administrator for Categorical Programs.

Since the formation of EPA, the Office of Pesticides Programs has been undergoing a nearly continuous reorganization. An organization chart essentially representative of the current structure of the pesticides program shows three primary divisions reporting to the Deputy Assistant Administrator through the Associate Deputy Assistant Administrator. These divisions are the Pesticides Regulation Division, the Pesticides Tolerances Division and the Division of Pesticides Community Studies. Also reporting to the Deputy Assistant Administrator are a Director of Program Development, several

special assistants and the Assistant for Administration. The two primary laboratories transferred to EPA, the Perrine Laboratory and the Gulf Breeze Laboratory, have since been shifted within EPA to the Assistant Administrator for Research and Monitoring.

The Pesticides Regulation Division is constituted primarily of those individuals transferred from the Agricultural Research Service of the Department of Agriculture. Their present functions are to register pesticides and their use to assure human safety and environmental quality and to determine compliance with pesticide labeling provisions.

The Pesticides Tolerances Division consists of personnel transferred to EPA from the Division of Regulations and Petitions Control, and the Residue Chemistry Branch, Residue Toxicology Branch and Petitions Evaluation Branch of the former Division of Pesticide Chemistry and Toxicology of the Food and Drug Administration. This Division's function is to establish tolerances for pesticide residues and to do research on effects of residues in humans and animals.

The Division of Pesticides Community Studies represents personnel from the former Office of Pesticides and Product Safety of the Food and Drug Administration. The existing Community Studies, State Services, and Technical Services branches of that unit in Food and Drug continue under the EPA organization. The Division also includes the former

Division of Pesticide Chemistry and Toxicology, except for the several branches that were placed in the Pesticides Tolerances Division - as mentioned above. The function of this Division is to conduct epidemiological studies on acute and chronic exposure to pesticides in communities and to study the toxic action of pesticides in small animals from low and high level exposure.

Early in 1970, an inter-departmental agreement was announced establishing a working group of the Subcommittee on Pesticides of the Cabinet Committee on the Environment. This interdepartmental agreement was for the purpose of coordination of the activities of the Departments of Agriculture, Interior, and Health, Education and Welfare, with respect to the control of economic poisons as defined in Section 2 of FIFRA. Administrative functions of the interdepartmental working group on pesticides is now in the Office of Pesticides Program of EPA. Review and action on policy matters under the working group are the responsibility of the Council on Environmental Quality which replaced the former Cabinet Committee on the Environment. The working group includes representation from the Department of Agriculture, HEW, Interior and Defense, as well as EPA. CEQ is an observer.

Not all functions with respect to pesticides in the Federal Government were transferred to EPA. The responsibility

of enforcement of EPA's tolerance levels in foods will remain in the Food and Drug Administration. FDA will also maintain surveillance programs to determine pesticide levels in foods. They will also continue research to improve analytical methods of determining pesticide levels in foods and studies on the long-term effects of pesticides on human health.

Although the functions of the Department of Agriculture under FIFRA were transferred to the Administrator, Environmental Protection Agency, the pesticides regulation and part of the monitoring activities - so transferred - were a small part of the overall responsibilities of the Agricultural Research Service in pesticides and related activities. The ARS is still responsible for research to develop improved means for pest and disease control of plants and animals, and to apply methods that are proven to assist the states in their plant and animal disease control programs. This research and assistance includes fundamental biology, improved means of non-pesticidal control, improved pesticide-use patterns, toxicology, pathology, metabolism, and fate of pesticides, pest control and protection of the environment during and after control operations, and pesticides management.

Significant activities with respect to various aspects of pesticide use will continue in other agencies of the federal government. For example, the Bureau of Sports

Fisheries and Wildlife in the Department of Interior expects to continue a group of pesticide-wildlife research projects, including related laboratory service work and research contracts. These represent studies of acute and chronic toxicity evaluations of pesticides and studies of the ecological and physiological effects through feeding tests and controlled plot studies using a variety of key bird and mammal species. Nearly \$1.75 million is scheduled for this activity in Fiscal Year 1972. The Forest Service of the Department of Agriculture has a continuing insect and disease control program. This will include the utilization of pesticides, as well as other means for the control of insects or other hazards attacking the forests of the country.

State Control Programs

As of mid-1971, 49 of the 50 states have enacted some form of pesticide control legislation. In some states such legislation has been on the books for at least 30 years. In recent years, the Association of American Pesticide Control Officials has prepared model legislation for the registration or control of pesticides sold or offered for sale or use within the state and for the registration or control of pesticide applicators. All but 10 of the states have enacted some form of registration or control of commercial applicators

of pesticides.

The model laws endorsed by the National Association of State Departments of Agriculture and incorporated in the advisory material published in the Council of State Governments State Legislation have not been uniformly adopted and implemented by the states. However, with the experience of several years and the increasing activity and concern of environmental and ecological groups seeking restrictions on the use of pesticides, the AAPCO has undertaken to revise the model laws. A draft of the AAPCO model pesticide law is included in the following pages.

The committee of the Association charged with developing a revision of the model law presented recommendations to the Association in mid-1971. Although these recommendations would normally have been accepted and distributed at that time, the developing legislation in Congress encouraged the Association to defer final action on the changes pending a better definition of the probable impact of the new Federal legislation. The chairman of the committee charged with developing the revision worked closely with the staff of the House Agricultural Committee throughout the hearings and the subsequent period of developing a "clean bill." He has endeavored to incorporate in the revised model law provisions to be consistent with and complementary to the anticipated new Federal statute.

DRAFT OF MODEL PESTICIDE USE AND APPLICATION ACT BY THE ASSOCIATION OF
AMERICAN PESTICIDE CONTROL OFFICIALS, AUGUST 1969

"An Act Relating to the application of insecticides, fungicides, herbicides, defoliant, desiccants, plant growth regulators, nematocides and any other pesticides by aircraft or ground equipment, or manually in the state of _____ be it enacted by the Legislature of the state of _____.

Section 1. Title. This Act shall be known as the "_____ Pesticide Use and Application Act of 19____".

Section 2. Enforcing Official. This Act shall be administered by the _____ of the state of _____, hereinafter referred to as the "_____".

Section 3. Declaration of Purpose. The purpose of this Act is to regulate in the public interest, the use and application of insecticides, fungicides, herbicides, defoliant, desiccants, plant growth regulators, nematocides, rodenticides, and any other pesticides designated by the _____ by regulation. New pesticides are continually being discovered or synthesized which are valuable for the control of insects, fungi, weeds, nematodes, rodents, and for use as defoliant, desiccants, plant regulators and related purposes. However, such pesticides may be ineffective or may seriously injure health, property, or wildlife if not properly used. Pesticides may injure man or animals, either by direct poisoning or by gradual accumulation of poisons in the tissues. Crops or other plants may also be injured by their improper use. The drifting or washing of pesticides into streams or lakes can cause appreciable damage to aquatic life. A pesticide applied for the purpose of killing pests in a crop, which is not itself injured by the pesticide, may drift and injure other crops or non-target organisms with which it comes in contact. Therefore, it is deemed necessary to provide for regulation of the use and application of such pesticides.

Section 4. Definitions. For the purpose of this Act—

(A) "Pest" means, but is not limited to, any insect, fungus, rodent, nematode, snail, slug, weed and any form of plant or animal life or virus (except virus on or in living man or other animal) which is normally considered to be _____.

(B) "Pesticide" means, but is not limited to, (1) any substance or mixture of substances, including any living organism or any product derived therefrom, intended to prevent, destroy, control, repel, attract, or mitigate any insect, rodent, nematode, snail, slug, fungus, weed and any other form of plant or animal life or virus (except virus on or in living man or other animal) which is normally considered to be a pest or which the _____ may declare to be a pest, and (2) any substance or mixture of substances intended to be used as a plant regulator, defoliant or desiccant, and (3) any spray adjuvant, such as a wetting agent, spreading agent, deposit builder, adhesive, emulsifying agent, deflocculating agent, water modifier, or similar agent with or without toxic properties of its own intended to be used with any other pesticide as an aid to the application or effect thereof, whether or not distributed in a package or container separate from that of the pesticide with which it is to be used, and (4) any other substances intended for such use as may be named by the _____ by regulation after calling a public hearing for such purpose.

(C) "Insecticide" means any substance or mixture of substances intended to prevent, destroy, repel, attract, or mitigate any insects which may be present in any environment whatsoever.

(D) "Fungicide" means any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any fungi.

(E) "Herbicide" means any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any weed.

(F) "Defoliant" means any substance or mixture of substances intended to cause the leaves or foliage to drop from a plant with or without causing abscission.

(G) "Desiccant" means any substance or mixture of substances intended to artificially accelerate the drying of plant tissues.

(H) "Plant Regulator" means any substance or mixture of substances intended through physiological action, to accelerate or retard the rate of growth or maturation, or to otherwise alter the behavior of plants but shall not include substances insofar as they are intended to be used as plant nutrients, trace elements, nutritional chemicals, plant inoculants or soil amendments.

(I) "Rodenticide" means any substance or mixture of substances intended to prevent, destroy, repel, attract, or mitigate rodents or any other vertebrate animal which the _____ may declare to be a pest.

(J) "Nematocide" means any substance or mixture of substances intended to prevent, destroy, repel, or mitigate nematodes.

(K) "Insect" means any of the numerous small invertebrate animals generally having the body more or less obviously segmented, for the most part belonging to the class Insecta, comprising six-legged, usually winged forms, as for example beetles, bugs, wasps, flies, and to other allied classes of arthropods whose members are wingless and usually have more than six legs, as for example spiders, mites, ticks, centipedes, and wood lice.

(L) "Fungi" means all nonchlorophyll-bearing tallophytes (that is, all non-chlorophyll-bearing plants of a lower order than mosses and liverworts) as, for example, rusts, smuts, mildews, molds, yeasts and bacteria, except those on or in living man or other animals.

(M) "Weed" means any plant or part thereof which grows where not wanted.

(N) "Nematode" means invertebrate animals of the phylum nemathelminthes and class nematoda, that is unsegmented round worms with elongated, fusiform, or sac-like bodies covered with cuticle, and inhabiting soil, water, plants, or plant parts; may also be called nemas or eelworms.

(O) "Snails or slugs" include all harmful mollusks.

(P) "Person" means any individual, firm, partnership, association, corporation, company, joint stock association, or body politic, or any organized group of persons whether incorporated or not; and includes any trustee, receiver, assignee, or other similar representative thereof.

(Q) "Equipment" means any type of ground, water or aerial equipment, device, or contrivance using motorized, mechanical or pressurized power and used to apply any pesticide on land and anything that may be growing, habitating or stored on or in such land, but shall not include any pressurized hand-sized household device used to apply any pesticide or any equipment, device or contrivance of which the person who is applying the pesticide is the source of power or energy in making such pesticide application.

(R) "Restricted use pesticide" means any pesticide, including any highly toxic pesticide, which the ——— has found and determined, subsequent to a hearing, to be injurious to persons, pollinating insects, bees, animals, crops, or lands, other than the pests it is intended to prevent, destroy, control, or mitigate.

(S) "Engage in business" means any application of pesticide by any person upon lands of another.

(T) "Board" means the pesticide advisory board.

(U) "Land" means all land and water areas, including airspace, and all plants, animals, structures, buildings, devices and contrivances, appurtenant thereto or situated thereon, fixed or mobile, including any used for transportation.

(V) "Pesticide Applicator" means any person who owns or manages a pesticide application business which is engaged in the business of applying pesticides upon the lands of another.

(W) "Pesticide Operator" means any person employed by a pesticide applicator who operates equipment for the application of pesticides or applies pesticides manually. This term does not include employees who work only under direct "on-the-job" supervision of a licensed pesticide applicator or licensed pesticide operator.

(X) "Public Operator" means any person in charge of any equipment used by state agencies, municipal corporations, public utilities, or other governmental agencies applying pesticides.

(Y) "Wildlife" means all living things that are neither human, domesticated, nor, as defined in this Act, pests; including, but not limited to mammals, birds, and aquatic life.

Section 5. ——— to Administer and Enforce Act and Adopt Regulations.

(A) The ——— shall administer and enforce the provisions of this Act and shall have authority to issue Regulations after a public hearing following due notice to all interested persons to carry out the provisions of this Act and in such Regulations may prescribe methods to be used in the application of pesticides. Where the ——— finds that such Regulations are necessary to carry out the purpose and intent of this Act such Regulations may relate to the time, place, manner, and method of application of the pesticides, may restrict or prohibit use of pesticides in designated areas during specified periods of time and shall encompass all reasonable factors which the ——— deems necessary to prevent damage or injury by drift or misapplication to:

- (1) Plants, including forage plants, or adjacent or nearby lands;
- (2) Wildlife in the adjoining or nearby areas;
- (3) Fish and other aquatic life in waters in reasonable proximity to the area to be treated;
- (4) Pollinating insects, animals, or persons.

In issuing such Regulations, the ——— shall give consideration to pertinent research findings and recommendations of other agencies of this state or of the federal government.

The ——— may by Regulation require that notice of a proposed application of a pesticide be given to land owners adjoining the property to be treated or in the immediate vicinity thereof, if he finds that such notice is necessary to carry out the purpose of this Act.

(B) The ——— may also by Regulation after a public hearing following due notice adopt a list of "restricted use pesticides" for the state or for designated areas within the state if he finds that the characteristics of such pesticides require that Regulations restricting their use by any person are necessary to prevent injury on lands other than the land to which they are applied or to persons, animals, crops, pests or vegetation other than the pests or vegetation which they are intended to destroy. The ——— may include in the Regulation the time and conditions of use of such restricted use pesticides and may, if he deems it necessary to carry out the provisions of this Act, require a permit for each application of a restricted use pesticide. Any order issued under this section shall be based only upon substantial evidence of record as a whole at the public hearing.

Section 6. Classification of License. The ——— may classify licenses to be issued under this Act. Such classifications may include but not be limited to pest control operators, ornamental or agricultural pesticide applicators, or right of way pesticide applicators. Separate classifications may be specified as to ground, aerial, or manual methods used by any licensee to apply pesticides. Each classification shall be subject to separate testing procedures and requirements; PROVIDED, That no person shall be required to pay an additional license fee if such person desires to be licensed in one or all of the license classifications provided for by the ——— under the authority of this section.

Section 7. Pesticide Applicator's License. No person shall engage in the business of applying pesticides to the lands of another within this state at any time without a pesticide applicator's license issued by the ———. The ——— shall require an annual fee of \$——— for each pesticide applicator's license issued and in addition an inspection fee of \$——— for each aircraft to be licensed and \$——— for each piece of ground equipment to be licensed. Should any equipment fail to pass inspection as per Section 16, making it necessary for a second inspection to be made, the ——— shall require an added inspection fee of \$———. In addition to the required inspection, unannounced inspections may be made without charge to determine if equipment is properly calibrated and maintained in conformance with laws and regulations.

(A) *Application for Pesticide Applicator's License—Form. Content.* Application for a license shall be made in writing to the ——— on a designated form obtained from said ——— office. Each application for a license shall contain information regarding the applicant's qualifications and proposed operations, license classification or classifications the applicant is applying for, and shall include the following:

- (1) The full name of the person applying for the license;
- (2) If the applicant is an individual, receiver, trustee, firm, partnership, association, corporation, or other organized group of persons whether or not incorporated, the full name of each member of the firm or partnership, or the names of the officers of the association, corporation, or group;
- (3) The principal business address of the applicant in the State and elsewhere;
- (4) The name and address of a person, who may be the Secretary of State, whose domicile is in the State, and who is authorized to receive and accept services of summons and legal notice of all kinds for the applicant;
- (5) The model, make, horsepower, and size of any equipment used by the applicant to apply pesticides;
- (6) Any other necessary information prescribed by the ———.

NOTE: Some states may wish to require all non-resident licensees to appoint a legal resident agent upon whom process may be served, thereby, making such non-resident amenable to the jurisdiction of the Courts of said State.

OPTION: "Any non-resident applying for a license under this Act to operate in the state of ——— shall file a written power of attorney designating the Secretary of State as the agent of such non-resident upon whom service of process may be had in the event of any suit against said non-resident person, and such power of attorney shall be so prepared and in such form as to render effective the jurisdiction of the Courts of the state of ——— over such non-resident applicant. PROVIDED, however, that any such non-resident who has a duly appointed resident agent upon whom process may be served as provided by law shall not be required to designate the Secretary of State as such agent. The Secretary of State shall be allowed such fees therefor as provided by law for designating resident agents. The ——— shall be furnished with a copy of such designation of the Secretary of State or of a resident agent, such copy to be duly certified by the Secretary of State."

(B) *Examination for Pesticide Applicator's License.* The ——— shall require an applicant for a license to show upon examination that he possesses adequate knowledge concerning the proper use and application of pesticides in the classifications he has applied for, manually or with the various equipment that he may have applied for a license to operate. The examination shall ———

- (1) The proper use of the equipment.
- (2) The hazards that may be involved in applying the pesticides, including:
 - (a) The effect of drift of the pesticides on adjacent and nearby lands and other non-target organisms;
 - (b) The proper meteorological conditions for the application of pesticides and the precautions to be taken therewith;
 - (c) The effect of the pesticides on plants or animals in the area, including the possibility of damage to plants or animals or the possibility of illegal pesticide residues resulting on them;
 - (d) The effect of the application of pesticides to wildlife in the area, including aquatic life;
 - (e) The identity and classification of pesticides used and the effects of their application in particular circumstances;
 - (f) The likelihood of contamination of water or injury to persons, plants, livestock, pollinating insects, and vegetation.
- (3) Calculating the concentration of pesticides to be used in particular circumstances.
- (4) Identification of common pests to be controlled and the damages caused by such pests.
- (5) Protective clothing and respiratory equipment required during the handling and application of pesticides.
- (6) General precautions to be followed in the disposal of containers as well as the cleaning and decontamination of the equipment which the applicant proposes to use.
- (7) Applicable State and Federal Pesticide Laws and Regulations.

(C) *Issue Pesticide Applicator's License.* If the ——— finds the applicant qualified to apply pesticides in the classifications he has applied for and, if the applicant files the bond or insurance required under Section 13 of this Act, and if the applicant applying for a license to engage in aerial application of pesticides has met all of the requirements of the Federal Aviation Agency and the Aeronautics Commission of this state to operate the equipment described in the application, the ——— shall issue a pesticide applicator license limited to the classifications for which he is qualified, which shall expire at the end of the calendar year of issue unless it has been revoked or suspended prior thereto by the ——— for cause.

OPTION: PROVIDED such financial security required under Section 13 of this Act is not dated to expire at an earlier date, in which case said license shall be dated to expire upon expiration date of said financial security. The license may restrict the applicant to the use of a certain type or types of equipment or pesticides or to certain areas if the ——— finds that the applicant is qualified to use only such type or types. If a license is not issued as applied for, the ——— shall inform the applicant in writing of the reasons therefor.

OPTION SECTION 8. Pesticide Operator's License—Application Date—Fee. It shall be unlawful for any person to act as an employee of a pesticide applicator and apply pesticides manually or as the operator directly in charge of any equipment which is licensed or should be licensed under the provisions of this chapter for the application of any pesticide, without having obtained an operator's license from the ———. Such an operator's license shall be in addition to any other license or permit required by law for the operation or use of any such equipment. Any person applying for such an operator's license shall file an application on a form prescribed by the ——— on or before January 1 of each year. Application for a license to apply pesticides shall be accompanied by a license fee of \$———. The provisions of this subsection shall not apply to any individual who has passed the examination provided for in Section 7(B), and is a licensed pesticide applicator.

If the ——— finds the applicant qualified to apply pesticides in the classifications he has applied for after examinations as provided for in Section 7(B) and if the applicant applying for a license to engage in aerial applications of pesticides has met all of the requirements of the Federal Aviation Agency and the Aeronautics Commission of this state to operate the equipment described in the application, the ——— shall issue a pesticide operator license limited to the classifications for which he is qualified which shall expire at the end of the

calendar year of issue unless it has been revoked or suspended prior thereto by the ——— for cause as provided for in Section 12 of this Act. If a license is not issued as applied for, the ——— shall inform the applicant in writing of the reasons therefor.

OPTION SECTION 9. Application of Act to Governmental Entities—Public Operator's License Required—Liability. All state agencies, municipal corporations, and public utilities or any other governmental agency shall be subject to the provisions of this Act and rules adopted thereunder concerning the application of restricted use pesticides by any person on their own crops or land: **PROVIDED**, That the public operators in charge of any equipment used by any state agencies, municipal corporations, public utilities, or any governmental agencies shall be subject to the provisions of Section 7(B) and Section 8 of the ——— shall issue a limited license without a fee to such public operators which shall be valid only when such public operators are acting as operators on equipment used by such entities. **PROVIDED FURTHER**, That government research personnel shall be exempt from this licensing requirement when applying pesticides to experimental plots.

(A) Such agencies, municipal corporations, and public utilities shall be subject to legal recourse by any person damaged by such application of any pesticide, and such action may be brought in the county where the damage or some part thereof occurred.

OPTION SECTION 10. Pest Control Consultant License

(A) **Definition.** As used in this Act, the term "pest control consultant" shall mean any person who, for a fee, offers or supplies technical advice, supervision, aid, or recommends the use of specific pesticides for the purpose of controlling insect pests, plant diseases, weeds, and other pests.

(B) **License, Application, and Fee.** No person shall perform services as a pest control consultant without first procuring from the ——— a license in the classifications he has applied for as per Section 6. Application for a license shall be on a form prescribed by the ——— and shall include the applicable information stipulated in Section 7(A). The application for a license shall be accompanied by an annual fee of \$——.

(C) **Qualifications.** Each applicant for a pest control consultant's license shall be required to present to the ——— satisfactory evidence of training and experience providing a basic background to understand pest control principles. Such applicant shall be required to pass satisfactorily a written examination to be prescribed by the ——— or his representative to demonstrate the applicant's specific knowledge as per Section 7(B).

Section 11. License Renewals—Penalty for Delinquent Renewals—Retesting. If the application for renewal of any license provided for in this chapter is not filed prior to January 1 in any year, a penalty of twenty-five percent shall be assessed and added to the original fee and shall be paid by the applicant before the renewal license shall be issued: **PROVIDED**, That such penalty shall not apply if the applicant furnishes an affidavit certifying that he has not engaged in the business subsequent to the expiration of his license. Any person holding a current valid license may renew such license for the next year without taking another examination unless the ——— determines that new knowledge related to classifications for which the applicant has applied makes a new examination necessary. However, if the license is not renewed by March 1 of each year then such licensee shall again be required to take another examination.

Section 12. Grounds for Denial, Suspension, Revocation of License. The ——— may suspend, pending inquiry, for not longer than ten days, and, after opportunity for a hearing, may deny, suspend, revoke, or modify the provision of any license issued under this Act, if he finds that the applicant or licensee has committed any of the following acts, each of which is declared to be a violation of this Act:

- (1) Made false or fraudulent claims through any media, misrepresenting the effect ———;
- (2) Made a pesticide recommendation or application not in accordance with the label registered by USDA and/or a ——— state registered use or was not an official recommendation of the ——— state land grant college or university;
- (3) Applied known ineffective or improper materials;
- (4) Operated faulty or unsafe equipment;
- (5) Operated in a faulty, careless, or negligent manner;
- (6) Refused or, after notice, neglected to comply with the provisions of this Act, the rules adopted hereunder, or of any lawful order of the ———;

(7) Refused or neglected to keep and maintain the records required by this chapter, or to make reports when and as required;

(8) Made false or fraudulent records, invoices, or reports;

(9) Engaged in the business of the application of a pesticide without having a licensed applicator or operator in direct "on-the-job" supervision.

(10) Operated unlicensed equipment.

(11) Used fraud or misrepresentation in making an application for a license or renewal of a license;

(12) Refused or neglected to comply with any limitations or restrictions on or in a duly issued license or permit.

(13) Aided or abetted a licensed or an unlicensed person to evade the provisions of this chapter, combined or conspired with such a licensed or an unlicensed person to evade the provisions of this chapter, or allowed one's license to be used by an unlicensed person;

(14) Made false or misleading statements during or after an inspection concerning any infestation or infection of pests found on land; or

(15) Impersonated any state, county, or city inspector or official.

Section 13. Surety Bond or Insurance Required of Pesticide Applicator Licensee. The _____ shall not issue a pesticide applicator's license until the applicant has furnished evidence of financial responsibility with the _____ consisting either of who may suffer legal damages as a result of the operations of the applicant; PROVIDED, That such surety bond or liability insurance policy need not apply to damages or injury to agricultural crops, plants or land being worked upon by the applicant.

(A) *Amount of Bond or Insurance Required—Notice of Reduction or Cancellation by Surety or Insurer.* The amount of the surety bond or liability insurance as provided for in this section shall be not less than \$_____ for property damage and public liability insurance, each separately, and including loss or damage arising out of the actual use of any pesticide. Such surety bond or liability insurance shall be maintained at not less than that sum at all times during the licensed period. The _____ shall be notified ten days prior to any reduction at the request of the applicant or cancellation of such surety bond or liability insurance by the surety or insurer; PROVIDED, That the total and aggregate of the surety and insurer for all claims shall be limited to the face of the bond or liability insurance policy; PROVIDED, FURTHER, That the _____ may accept a liability insurance policy or surety bond in the proper sum which has a deductible clause in an amount not exceeding \$_____ for aerial applicators and \$_____ for all other applicators for the total amount of liability insurance or surety bond required herein; AND PROVIDED FURTHER, That if the applicant has not satisfied the requirement of the deductible amount in any prior legal claim such deductible clause shall not be accepted by the _____ unless such applicant furnishes the _____ with a surety bond or liability insurance which shall satisfy the amount of the deductible as to all claims that may arise in his application of pesticides.

(B) *Cancellation of License when Bond or Insurance Reduced Below Minimum Requirements.* Should the surety furnished become unsatisfactory, said applicant shall upon notice execute a new bond or insurance and shall he fail to do so, the _____ shall cancel his license and give him notice of said fact and it shall be unlawful thereafter for such person to engage in said business of applying pesticides until the bond or insurance is brought into compliance with the requirements of Section 13 (A) and his license is reinstated by the _____.

(C) *Personal Liability for Damage.* Nothing in this Act shall be construed to relieve any person from liability for any damage to the person or lands of another caused by the use of pesticides even though such use conforms to the rules and regulations of the _____.

Section 14. Damaged Person Must File Report of Loss—Contents—Time for Filing—Effect of Failure to File. The person claiming damages from pesticide application shall have filed with the _____ a written statement claiming that he has been damaged, on a form prescribed by the _____ within sixty (60) days after the date that damages occurred, or prior to the time that twenty-five (25) percent of a crop damaged shall have been harvested. Such statement shall contain, but shall not be limited thereto, the name of the person responsible for the application of said pesticide, the name of the owner or lessee of the land on which the crop is grown and for which damages are claimed and the date on which it is alleged that the damage occurred. The _____ shall prepare a form to be furnished to persons to be used in such cases and such form shall contain such other re-

quirement as the ——— may deem proper. The ——— shall, upon receipt of such statement, notify the licensee and the owner or lessee of the land or other person who may be charged with the responsibility, for the damages claimed, and furnish copies of such statements as may be requested.

The filing of such report or the failure to file such a report need not be alleged in any complaint which might be filed in a court of law, and the failure to file the report shall not be considered any bar to the maintenance of any criminal or civil action.

The failure to file such a report shall not be a violation of this Act. However, if the person failing to file such report is the only one injured from such use or application of a pesticide by others, the ——— may, when in the public interest, refuse to hold a hearing for the denial, suspension, or revocation of a license or permit issued under this Act until such report is filed.

Where damage is alleged to have been done, the claimant shall permit the licensee and his representatives, such as bondsman or insurer to observe within reasonable hours the lands or non-target organism alleged to have been damaged in order that such damage may be examined. Failure of the claimant to permit such observation and examination of the damaged lands shall automatically bar the claim against the licensee.

Section 15. Licensees to Keep Records—Duration—Submission to ———. The ——— shall require licensees to maintain records with respect to applications of pesticides. Such relevant information as the ——— may deem necessary may be specified by regulation. Such records shall be kept for a period of ——— years from the date of the application of the pesticide to which such records refer, and the ——— shall, upon request in writing, be furnished with a copy of such records forthwith by the licensee.

Section 16. Inspection of Equipment. The ——— may provide for inspection of any equipment used for application of pesticides and may require repairs or other changes before its further use for pesticide application. A list of requirements that equipment shall meet may be adopted by regulation.

Option Section 17. License Plates for Equipment. All licensed equipment shall be identified by a license plate or decal furnished by the ———, at no cost to the licensee, which plate shall be affixed in a location and manner upon such equipment as prescribed by the ———.

Option Section 18. Reciprocal Agreement. The ——— may issue a license on a reciprocal basis with other states without examination to a non-resident who is licensed in another state substantially in accordance with the provisions of this Act; *Provided*, That financial security as provided for in Section 13 of this Act is met.

Section 19. Exemptions.

Option (A) Farmer Exemption. The provisions of this Act relating to licenses and requirements for their issuance shall not apply to any farmer owner of ground equipment applying pesticides for himself or his farmer neighbors; *PROVIDED*, That

1. He operates farm property and operates and maintains pesticide application equipment primarily for his own use.

2. He is not regularly engaged in the business of applying pesticides for hire amounting to a principal or regular occupation and that he shall not publicly hold himself out as a pesticide applicator.

3. He operates his pesticide application equipment only in the vicinity of his own property and for the accommodation of his neighbors.

OPTION (B) Landscape Gardener Exemption. The provisions of this Act shall not apply to any person using hand-powered equipment, devices, or contrivances to apply pesticides to lawns, or to ornamental shrubs and trees not in excess of twelve feet high, as an incidental part of his business of taking care of household lawns and yards for remunerations; *PROVIDED*, That such person shall not publicly hold himself out as being in the business of applying pesticides.

OPTION (C) PCO Exemption. (NOTE: The following exemption should be used only if another statute regulates this classification.) This Act shall not apply to persons applying pesticides only to prevent, destroy, repel, or mitigate insects or fungi within or under buildings or within vehicles, ships, aircraft, or other means of transporting persons or property by land, water, or air.

Section 20. Discarding and Storing of Pesticides and Pesticide Containers. No person shall discard or store any pesticide or pesticide containers in such a manner as to cause injury to humans, vegetation, crops, livestock, wildlife, pollinating insects or to pollute any waterway in a way harmful to any wildlife therein. The

— may promulgate rules and regulations governing the discarding and storing of such pesticides or pesticide containers.

OPTION SECTION 21. Pesticide Advisory Board—Composition, Terms. There is hereby created a pesticide advisory board consisting of three licensed pesticide applicators residing in the state, one shall be licensed to operate ground equipment, one shall be licensed to operate aerial equipment, and one shall be licensed for structural pest control; one entomologist in public service; one environmental health specialist from the — state department of health; one toxicologist in public service; one plant pathologist in public service; one member from the agricultural chemical industry; one member from the food processing industry; two producers of agricultural crops or products on which pesticides are applied or which may be affected by the application of pesticides; one representative of the — state department of agriculture; and one representative of the — state — agency responsible for the protection of fish and wildlife. Such members shall be appointed by the governor for terms of four years and may be appointed for successive four year terms at the discretion of the governor. The governor may remove any member of the board prior to the expiration of his term of appointment for cause: PROVIDED, That at the inception of this chapter the governor shall appoint four members, which shall not include two members from any one representative group for a period of two years; four members for a period of three years which shall not include two members from any one representative group; and five members for a period of four years which shall not include two members from any one representative group. All subsequent terms for appointments to such board shall be for a period of four years.

(A) **Vacancies.** Upon the death, resignation, or removal for cause of any member of the board, the governor shall fill such vacancy, within thirty days of its creation, for the remainder of its term in the manner herein prescribed for appointment to the board.

(B) **General Powers and Duties.** The board shall advise the — on any or all problems relating to the use and application of pesticides in the state.

(C) **Officers—Meetings.** The board shall elect one of its members chairman. The members of the board shall meet at such time and at such place as shall be specified by the call of the —, chairman, or a majority of the board.

Section 22. Legal Recourse. Any person aggrieved by any action of the — may obtain a review thereof by filing in the — court within thirty (30) days of notice of the action a written petition praying that the action of the — be set aside. A copy of such petition shall forthwith be delivered to the —, and within — days thereafter the — shall certify and file in the court a transcript of any record pertaining thereto, including a transcript of evidence received, whereupon the court shall have jurisdiction to affirm, set aside or modify the action of the —, except that the findings of the — as to the facts, if supported by substantial evidence, shall be conclusive.

Section 23. Information. The — may, in cooperation with the Land Grant College (University) publish information and conduct short courses of instruction in the safe use and application of pesticides.

Section 24. Penalty. Any person violating the provisions of this Act or the Regulations issued hereunder shall be guilty of a misdemeanor. (The amount of the fine or term of imprisonment per penalty will depend on the situation in the state concerned.)

Section 25. Subpoenas. The — may issue subpoenas to compel the attendance of witnesses and/or production of books, documents, and records anywhere in the state in any hearing affecting the authority or privilege granted by a license or permit issued under the provisions of this Act.

Section 26. Enforcement. For the purpose of carrying out the provisions of this Act the — may enter upon any public or private premises at reasonable times, in order:

- (1) To have access for the purpose of inspecting any equipment subject to this Act and such premises on which such equipment is kept or stored; or
- (2) To inspect lands actually or reported to be exposed to pesticides; or
- (3) To inspect storage or disposal areas; or
- (4) To inspect or investigate complaints of injury to humans or land; or
- (5) To sample pesticides being applied or to be applied.

Should the — be denied access to any land where such access was sought for the purposes set forth in this Act, he may apply to any court of competent jurisdiction for a search warrant authorizing access to such land for said purposes. The court may upon such application, issue the search warrant for the purposes requested.

An Act relating to the application of insecticides, fungicides, herbicides, defoliants, desiccants, plant growth regulators, nematocides and any other pesticides by aircraft or ground equipment, or manually in the state of _____ be it enacted by the legislature of the State of _____."

INTERPRETIVE STATEMENT

Background

The "Model Pesticide Use and Application Act" has been developed to update and expand the 1951 act entitled "An Act Relating to the Application of Insecticides, Fungicides, and Herbicides by Aircraft or Ground Equipment." This redrafting project was undertaken by the Association of American Pesticide Control Officials, whose members are responsible for enforcing such state laws. In addition to review by state officials, this proposal has been studied and amended by other interested parties such as the National Agricultural Chemicals Association, National Aerial Applicators Association, United States Department of Agriculture, Food & Drug Administration, and National Association of State Directors of Agriculture. The authority provided in this act is in addition to, and coordinated with, the responsibilities of the "Uniform State Insecticide, Fungicide, and Rodenticide Act."

Problem

There is increasing need for enabling legislation that provides broad authority at state level to regulate the application and use of pesticides. The gap in responsibility between the Pesticide Regulations Division's federally registered label for a pesticide formulation intended for interstate shipment and the Food & Drug Administration's sampling and analyzing of feed and food following harvest is continually increasing.

Historically, enactment of such laws has been within the realm of state regulatory responsibility. Effective control of pesticide usage can only be administered at the local level due to the differences between and within states in the size and type of agriculture, the seriousness of pest control problems, population, existing laws, climate, and other environmental and ecological factors. Although there are advantages to uniformity, it is apparent that model enabling legislation must be flexible enough to allow for differing regulations, appropriate for each area with its problems and particular needs.

Only through efficient management of pesticide usage will we be able to minimize the incidents of misuse that can result in the banning of chemicals essential for controlling pests. Approximately twenty states have no laws regulating the use of pesticides and many of the laws enacted have limited authority. Both the Mark Committee, commissioned by HEW, and the USDA have recommended that states enact more comprehensive legislation and implement improved programs to regulate pesticide usage.

Explanation

Each proposal in this act has been enacted by at least one state legislature and has been successfully administered. While the act provides adequate authority to protect the general public, it is reasonable and should be acceptable to state legislators, growers, and the pesticide application industry. It was drafted so that certain options could be enacted or omitted without impairing the basic continuity of the act.

Of particular importance, this new act expands authority over the 1951 act to:

1. Declare certain pesticides "restricted use pesticides" when the administrative agency finds that the characteristics of the pesticide require additional restrictions which may include permits for application. These restrictions apply to growers and home owners as well as commercial applicators covered under the prior bill.

2. To license and test commercial pesticide operators (employees) as well as the applicator (owner or manager).

3. To license and test public operators (employees of state agencies, municipal corporations, and public utilities).

4. To license and test "pest control consultants"; persons who for a fee supply technical advice, supervision, or recommend the use of specific pesticides.

5. Establish a Pesticide Advisory Board. The makeup of this board might vary in different states but the intent is that the board advise the administrative agency rather than control the administrative agency, such as is suggested in the Model Pesticide Control Act, proposed by the Environmental Defense Fund.
6. Cover pesticide applications applied manually as well as those applied with licensed aerial or ground equipment.

ERRETT DECK,

Chairman, Model Pesticide Use & Application Bill Committee, Association of American Pesticide Control Officials.

(The proposed amendments are as follows:)

PROPOSED AMENDMENT NO. 1

Add the words underlined in Sec. 4(d) (2) lines 18 et. seq., "As used in this subsection, the term "approved pesticide applicator" means any person who uses any pesticide for any purpose specified in subsection 2(a) of this Act and (a) who has a license or certificate of competence issued by the state in which such operations are conducted . . ."

PROPOSED AMENDMENT NO. 2

Add the words underlined in Sec. 4(d) (3) lines 21 et. seq., "As used in this subsection, the term "approved pest management consultant" means any person who has a license or certificate of competence issued by a state . . ."

PROPOSED AMENDMENT NO. 3

Add Subsection 9(f) as follows:

"The administrator may require that all warehouses, carriers, distributors, and dealers handling pesticides registered for "restricted use" or "for use by permit only" register with an appropriate agency of state government or with the administrator."

PROPOSED AMENDMENT NO. 4

Amend Section 16(a) by adding the words underlined as follows:

"All authority vested in the administrator by virtue of provisions of this Act may with like force and effect be executed by such employees of the Environmental Protection Agency or an agency of state or local government with which a contract as specified in subsection 16(c) is in effect as the administrator may designate for the purpose."

PROPOSED AMENDMENT NO. 5

Add Subsection 16(c) as follows:

"The administrator is further authorized to enter into contracts with federal, state, or local agencies to carry out the field inspection and laboratory analyses of pesticides, the residue monitoring programs, and the inspection of operations carried out by approved pesticide applicators, or approved pesticide consultants under the provisions of this Act."

The federal regulation of pesticides operates under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), enacted in 1947 and amended in 1959, 1961 and 1964. The law uses the term "economic poisons" to include: (1) "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or animals," and (2) "any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant." The act prohibits the interstate or international shipment of economic poisons unless they: are registered pursuant to provisions of Section 4 of the act, are in unbroken immediate containers, and are labeled according to the provisions of the act. Authorities under the act were assigned to the Secretary of the Department of Agriculture and have since been transferred to the Administrator of the Environmental Protection Agency. The act defines the process of registration and provides the mechanisms by which the Administrator may refuse registration of an economic poison or may cancel a registration. In the event of a refusal or a cancellation of a registration, the applicant or registrant has several courses of appeal opened to him. These include the referral of the matter to an advisory committee or the holding of a public hearing. If the

applicant requests the referral to an advisory committee, he has 30 days in which to make such a request. Thereafter, the Administrator shall convene such advisory committee and the committee has at least 60 days, and can have as many as 120 days, in which to file its findings with the Administrator. The Administrator then has an additional 90 days to consider the report and recommendations of the advisory committee and make his determination. The applicant, thereafter, has an additional 60 days from date of the order of the Administrator to file objections and request a public hearing. The Administrator shall, "after due notice," hold such public hearing for receiving evidence relevant and material to the issues raised by such objections. Not later than 90 days after the hearing, the Administrator shall issue an order based on the evidence of the hearing, including recommendations, underlying data and reasons. Even after this lengthy procedure, the applicant has within 60 days of the issue of such an order the opportunity to file an appeal with the United States Court of Appeals.

In the event of a cancellation of a registration, the registrant may continue to sell his product during this period of appeals. Should the Administrator find that an imminent hazard to the public would exist, he may suspend the registration of an economic poison immediately.

Any person who distributes, sells or offers for sale in interstate commerce an economic poison which is not registered, or which is not in the unbroken labeled container, or that is not properly labeled, or is in any fashion adulterated or misbranded, is guilty of a misdemeanor and on conviction can be fined not more than \$1,000.

New Federal Legislation

During 1971, Congress has considered legislation to amend or replace FIFRA. At least eight different bills dealing with pesticides were introduced in the House of Representatives. The primary one was H. R. 4152. In the Senate four bills have been under consideration, two of which (S. 600 and S. 745) would - like H. R. 4152 - replace the present FIFRA. The other bills would either prohibit the sale of DDT or prohibit the sale of aldrin, chlordane, DDD/TDE, dieldrin, endrin, heptachlor, lindane, and toxaphene. The fate of any legislation in the Congress is to be considered uncertain until enacted by both Houses and sent to the President. H. R. 10729, the Committee rewrite of H. R. 4152, was enacted by the House in the first session of the 92nd Congress. There is strong expectation that Senate action in the 1972 session will result in enactment of a new FIFRA very similar to H. R. 10729.

H. R. 10729 was originally an Administration bill. It incorporates many of the provisions of the existing law (FIFRA), but goes well beyond it in the federal regulation of intrastate as well as interstate activities, including registration of pesticides in intrastate commerce. It provides for the classification of pesticides as to: (a) "general use" or (b) "restricted use." The original versions had a third category of "use by permit only." It also provides for the certification of pesticide applicators. This is particularly pertinent in the context of pesticides registered for restricted use only. It provides for aid and guidance to states in developing training programs for pesticide applicators and for the certification of individuals entitled to use restricted pesticides.

The bill also substantially increases the enforcement powers of the federal agency. They provide authority to stop sale, use, or removal, extend the authority of seizure to intrastate shipments, and greatly increase the assigned penalties. There are provisions for criminal misdemeanor and for civil penalties, one of which is far greater than those of FIFRA. These include not only the registrant, wholesaler, dealer, retailer, or other distributor, but also the commercial pesticide applicator whose liability is in the same range as the commercial group previously cited.

In addition, there are now provisions for penalties of the private pesticide applicator. This can include the farmer who "knowingly violates any provision of this Act." In speaking to the authority of the states with respect to pesticides, the legislation provides that a state may regulate the sale or use of any pesticide or device in the state, but only if and to the extent the regulation does not permit any sale or use prohibited by the Act. Similarly, the state is not allowed to impose requirements for labeling and packaging in addition to or different from those required under the Act. There is a provision, however, for the state to assist the Administrator in the registration of pesticides formulated for intrastate distribution to meet specific local needs.

Impact of the Pending Legislation

A sampling of views from Congressional offices for the five study states of Minnesota, Illinois, Iowa, Missouri, and Kansas showed a general uniformity in rationale for and expected impact from the legislation. There was a consistent view that the pesticide control legislation was an integral part of the overall efforts at more effective pollution control. Constructive effects of the legislation in this respect were seen as including improved control of the practices of both commercial applicators and private applicators

to prevent the use of excessive amounts of pesticides or the careless application with resultant contamination of adjacent areas and streams; more effective control in the handling of pesticide containers; reduction in on-site storage of pesticides; and more effective control over the disposition of stocks of pesticides subject to recall on order of the Administrator.

It was noted that this Congressional support represented a response to please state officials for a national pattern of minimum standards on pesticide management. The bill, as finally enacted by the House, does not restrict a state from imposing more strict controls over pesticide products found to be particularly hazardous or unacceptable for use in that particular state.

There seemed to be a general concurrence from the farm community on the need for legislation of this general nature. On the whole, the Congressional offices reported very little reaction from constituents in their districts. Mail or other communication they received expressed approval for passage of the legislation. One office reported comments that the uniform national legislation was long overdue.

It should be noted that the contractor's own survey of farmers and agents in the five-state area strongly reinforces these views. Farmers and agents generally saw the need for some kind of legislation but most were afraid that

the intended bill or some variation of it, was designed to "take away all pesticides." They were, of course, distressed by this prospect. Clearly, an informational gap existed (exists) here. Farmers by and large demonstrated a real awareness of the problems unrestricted pesticide use could bring and further indicated a keen sense of environmental awareness. However, it should be pointed out that very few saw their individual acts as a part of a global picture of pesticide accumulation and contamination. The greatest opposition, as might have been suspected, came from some retailers who were also applicators and some commercial applicators - both saw impending legislation as entirely too restrictive upon them and without foundation. In defense of an equally large number of commercial applicators who honestly try to perform a service for farmers, it can be said that many are conscientious, dedicated entrepreneurs who dislike being blamed for the carelessness of others.

The contractor received numerous comments about unscrupulous activities of a minority of operators who crossed and recrossed state lines without proper authority, spraying from unlabeled bags of unidentified materials and moving on. Farmers and agents alike seemed aware of these practices and the more responsible ones condemned them. The provisions of the new bill (10729) specifically cover such activities and aside from the educational benefits and cost savings to farmers resulting from more efficient use, provide such

penalties as to make clandestine activities quite unprofitable if apprehended.

Several of the Congressional offices stressed the anticipated role of the Department of Agriculture and, in particular, the Federal-State-County system of agricultural extension agents in the education of farmers on more effective use of pesticides. The Department of Agriculture was reported as committing itself to a major effort in preparing the farmers who will seek certification as private applicators for the use of restricted category pesticides. Numerous side benefits, in terms of more efficient use of agricultural chemicals, are anticipated from this effort. Also stressed was the intent to stimulate greater efforts on alternative methods of control. The research support provisions in the legislation were specifically pointed out in this context.

With respect to the potential impact of the legislation on state programs, each office seemed to feel that the legislation in no way diminished the role of the states in pesticide control. It was pointed out that the states play a major role in the agricultural extension service and, thus, would have major responsibilities with respect to the certification of pesticide applicators. Beyond this, the nature of any modification that might be called for will be better determined when the program has been implemented and

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

(7 U.S.C. 135-135k)

Approved June 25, 1947 (61 Stat. 163) as amended by the Nematocide, Plant Regulator, Defoliant, and Desiccant Amendment of 1959 (73 Stat. 286) as amended by the Act of March 29, 1961 (75 Stat. 18) and the Act of April 7, 1961 (75 Stat. 42) and the Act of May 12, 1964 (P.L. 88-305, 78 Stat. 190)

An Act to regulate the marketing of economic poisons and devices, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled.

Title

Sec. 1. This Act may be cited as the "Federal Insecticide, Fungicide, and Rodenticide Act."

Definitions

Sec. 2 For the purposes of this Act—

a. The term "economic poison" means (1) any substance or mixtures of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or other animals, which the Secretary shall declare to be a pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

b. The term "device" means any instrument or contrivance intended for trapping, destroying, repelling, or mitigating insects or rodents or destroying, repelling, or mitigating fungi, nematodes, or such other pests as may be designated by the Secretary, but not including equipment used for the application of economic poisons when sold separately therefrom.

c. The term "insecticide" means any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insects which may be present in any environment whatsoever.

d. The term "fungicide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any fungi.

e. The term "rodenticide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating rodents or any other vertebrate animal which the Secretary shall declare to be a pest.

f. The term "herbicide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any weed.

g. The term "Nematocide" means any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating nematodes.

h. The term "plant regulator" means any substance or mixture of substances intended through physiological action, for accelerating or retarding the rate of growth or rate of maturation, or for otherwise altering the behavior of ornamental or crop plants or the produce thereof, but shall not include substances to the extent that they are intended as plant nutrients, trace elements, nutritional chemicals, plant inoculants, and soil amendments.

i. The term "defoliant" means any substance or mixture of substances intended for causing the leaves or foliage to drop from a plant, with or without causing abscission.

j. The term "desiccant" means any substance or mixture of substances intended for artificially accelerating the drying of plant tissue.

k. The term "nematode" means invertebrate animals of the phylum nemathelminthes and class nematoda. that is, unsegmented round worms with elongated, fusiform, or saclike bodies covered with cuticle, and inhabiting soil, water, plants or plant parts; may also be called nemas or eelworms.

l. The term "weed" means any plant which grows where not wanted.

m. The term "insect" means any of the numerous small invertebrate animals generally having the body more or less obviously segmented, for the most part belonging to the class insecta, comprising six-legged, usually winged forms, as, for example, beetles, bugs, bees, flies, and to other allied classes of arthropods whose members are wingless and usually have more than six legs, as, for example, spiders, mites, ticks, centipedes, and wood lice.

n. The term "fungi" means all non-chlorophyll-bearing thallophytes (that is, all non-chlorophyll-bearing plants of a lower order than mosses and liverworts) as, for example, rusts, smuts, mildews, molds, yeasts, and bacteria, except those on or in living man or other animals.

o. The term "ingredient statement" means either—

- (1) a statement of the name and percentage of each active ingredient, together with the total percentage of the inert ingredients, in the economic poison; or
- (2) a statement of the name of each active ingredient, together with the name of each and total percentage of the inert ingredients, if any there be, in the economic poison (except option 1 shall apply if the preparation is highly toxic to man, determined as provided in section 6 of this Act); and, in addition to (1) or (2) in case the economic poison contains arsenic in any form, a statement of the percentages

26-H

of total and water soluble arsenic, each calculated as elemental arsenic.

p. The term "active ingredient" means—

(1) in the case of an economic poison other than a plant regulator, defoliant or desiccant, an ingredient which will prevent, destroy, repel, or mitigate insects, nematodes, fungi, rodents, weeds, or other pests:

(2) in the case of a plant regulator, an ingredient which, through physiological action, will accelerate or retard the rate of growth or rate of maturation or otherwise alter the behavior or ornamental or crop plants of the produce thereof:

(3) in the case of a defoliant, an ingredient which will cause the leaves or foliage to drop from a plant;

(4) in the case of a desiccant, an ingredient which will artificially accelerate the drying of plant tissue.

q. The term "inert ingredient" means an ingredient which is not active.

r. The term "antidote" means a practical immediate treatment in case of poisoning and includes first-aid treatment.

s. The term "person" means any individual, partnership, association, corporation or any organized group of persons whether incorporated or not.

t. The term "Territory" means any Territory or possession of the United States, excluding the Canal Zone.

u. The term "Secretary" means the Secretary of Agriculture.

v. The term "registrant" means the person registering any economic poison pursuant to the provisions of this Act.

w. The term "label" means the written, printed, or graphic matter on, or attached to, the economic poison or device or the immediate container thereof, and the outside container or wrapper of the retail package, if any there be, of the economic poison or device.

x. The term "labeling" means all labels and other written, printed, or graphic matter—

(1) upon the economic poison or device of any of its containers or wrappers;

(2) accompanying the economic poison or device at any time;

(3) to which reference is made on the label or in literature accompanying the economic poison or device, except to current official publications of the United States Department of Agriculture and Interior, the United States Public Health Service, State experiment stations, State agricultural colleges, and other similar Federal or State institutions or agencies authorized by law to conduct research in the field of economic poisons.

y. The term "adulterated" shall apply to any economic poison if its strength or purity falls below the professed standard of quality as expressed on its labeling or under which it is sold, or if any substance has been substituted wholly or in part for the article, or if any valuable constituent of the article has been wholly or in part abstracted.

z. The term "misbranded" shall apply—

(1) to any economic poison or device if its labeling bears any statement, design, or graphic representa-

tion relative thereto or to its ingredients which is false or misleading in any particular;

(2) to any economic poison—

(a) if it is an imitation of or is offered for sale under the name of another economic poison;

(b) if its labeling bears any reference to registration under this Act other than the registration number assigned to the economic poison;

(c) if the labeling accompanying it does not contain directions for use which are necessary and if complied with adequate for the protection of the public;

(d) if the label does not contain a warning or caution statement which may be necessary and if complied with adequate to prevent injury to living man and other vertebrate animals, vegetation, and useful invertebrate animals;

(e) if the label does not bear an ingredient statement on that part of the immediate container and on the outside container or wrapper, if there be one, through which the ingredient statement on the immediate container cannot be clearly read, of the retail package which is presented or displayed under customary conditions of purchase: Provided That the Secretary may permit the ingredient statement to appear prominently on some other part of the container, if the size or form of the container makes it impracticable to place it on the part of the retail package which is presented or displayed under customary conditions of purchase;

(f) if any word, statement, or other information required by or under authority of this Act to appear on the label or labeling is not prominently placed thereon with such conspicuousness (as compared with other words, statements, designs, or graphic matter in the labeling) and in such terms as to render it likely to be read and understood by the ordinary individual under customary conditions or purchase and use;

(g) if in the case of insecticide, nematocide, fungicide, or herbicide when used as directed or in accordance with commonly recognized practice it shall be injurious to living man or other vertebrate animals, or vegetation, except weeds, to which it is applied, or to the person applying such economic poison; or

(h) if in the case of a plant regulator, defoliant, or desiccant when used as directed it shall be injurious to living man or other vertebrate animals, or vegetation to which it is applied, or to the person applying such economic poison: Provided, That physical or physiological effects on plants or parts thereof shall not be deemed to be injury, when this is the purpose for which the plant regulator, defoliant, or desiccant was applied, in accordance with the label claims and recommendations.

Prohibited Acts

Sec. 3. a. It shall be unlawful for any person to distribute, sell, or offer for sale in any Territory or in the District of Columbia, or to ship or deliver for shipment from any State, Territory, or the District of Columbia to

27-H

any other State, Territory, or the District of Columbia, or to any foreign country, or to receive in any State, Territory, or the District of Columbia from any other State, Territory, or the District of Columbia, or foreign country, and having so received, deliver or offer to deliver in the original unbroken package to any other person, any of the following:

- (1) Any economic poison which is not registered pursuant to the provisions of section 4 of this Act, or any economic poison if any of the claims made for it or any of the directions for its use differ in substance from the representations made in connection with its registration, or if the composition of an economic poison differs from its composition as represented in connection with its registration: Provided, That in the discretion of the Secretary, a change in the labeling or formula of an economic poison may be made within a registration period without requiring reregistration of the product.
- (2) Any economic poison unless it is in the registrant's or the manufacturer's unbroken immediate container, and there is affixed to such container, and to the outside container or wrapper of the retail package, if there be one, through which the required information on the immediate container cannot be clearly read, a label bearing—
 - (a) the name and address of the manufacturer, registrant, or person for whom manufactured;
 - (b) the name, brand, or trade-mark under which said article is sold;
 - (c) the net weight or measure of the content: Provided, That the Secretary may permit reasonable variations; and
 - (d) when required by regulation of the Secretary to effectuate the purposes of this Act, the registration number assigned to the article under this Act.
- (3) Any economic poison which contains any substance or substances in quantities highly toxic to man, determined as provided in section 6 of this Act, unless the label bear, in addition to any other matter required by this Act—
 - (a) the skull and crossbones;
 - (b) the word "poison" prominently (IN RED) on a background of distinctly contrasting color; and
 - (c) a statement of an antidote of the economic poison.
- (4) The economic poisons commonly known as standard lead arsenate, basic lead arsenate, calcium arsenate, magnesium arsenate, zinc arsenate, zinc arsenite, sodium fluoride, sodium fluosilicate, and barium fluosilicate unless they have been distinctly colored or discolored as provided by regulations issued in accordance with this Act, or any other white powder economic poison which the Secretary, after investigation of and after public hearing on the necessity for such action for the protection of the public health and the feasibility of such coloration or discoloration, shall, by regulation, require to be distinctly colored or discolored, unless it has been so colored or discolored: Provided, That the Secretary may exempt any economic poison to

the extent that it is intended for a particular use or uses from the coloring or discoloring required or authorized by this section if he determines that such coloring or discoloring for such use or uses is not necessary for the protection of the public health.

- (5) Any economic poison which is adulterated or misbranded or any device which is misbranded.

b. Notwithstanding any other provisions of this Act, no article shall be deemed in violation of this Act when intended solely for export to any foreign country and prepared or packed according to the specifications or directions of the foreign purchaser.

c. It shall be unlawful—

- (1) for any person to detach, alter, deface, or destroy, in whole or in part, any label or labeling provided for in this Act or the rules and regulations promulgated hereunder, or to add any substance to, or take any substance from an economic poison in a manner that may defeat the purpose of this Act;
- (2) for any manufacturer, distributor, dealer, carrier, or other person to refuse, upon a request in writing specifying the nature or kind of economic poison or device to which such request relates, to furnish to or permit any person designated by the Secretary to have access to and to copy such records as authorized by section 5 of this Act;
- (3) for any person to give a guaranty or undertaking provided for in section 7 which is false in any particular, except that a person who receives and relies upon a guaranty authorized under section 7 may give a guaranty to the same effect, which guaranty shall contain in addition to his own name and address the name and address of the person residing in the United States from whom he received the guaranty or undertaking; and
- (4) for any person to use for his own advantage or to reveal, other than to the Secretary, or officials or employees of the United States Department of Agriculture or other Federal agencies, or to the courts in response to a subpoena, or to physicians, and in emergencies to pharmacists and other qualified persons, for use in the preparation of antidotes, in accordance with such directions as the Secretary may prescribe, any information relative to formulas of products acquired by authority of section 4 of this Act.

Registration

Sec. 4. a. Every economic poison which is distributed, sold, or offered for sale in any Territory or the District of Columbia, or which is shipped or delivered for shipment from any State, Territory, or the District of Columbia to any other State, Territory, or the District of Columbia, or which is received from any foreign country shall be registered with the Secretary: Provided, That products which have the same formula, are manufactured by the same person, the labeling of which contains the same claims, and the labels of which bear a designation identifying the product as the same economic poison may be registered as a single economic poison: and additional

names and labels shall be added by supplement statements; the applicant for registration shall file with the Secretary a statement including

(1) the name and address of the registrant and the name and address of the person whose name will appear on the label, if other than the registrant;

(2) the name of the economic poison.

(3) a complete copy of the labeling accompanying the economic poison and a statement of all claims to be made for it, including the directions for use; and

(4) if requested by the Secretary, a full description of the tests made and the results thereof upon which the claims are based.

b. The Secretary, whenever he deems it necessary for the effective administration of this Act, may require the submission of the complete formula of the economic poison. If it appears to the Secretary that the composition of the article is such as to warrant the proposed claims for it and if the article and its labeling and other material required to be submitted comply with the requirements of section 3 of this Act, he shall register it.

c. If it does not appear to the Secretary that the article is such as to warrant the proposed claims for it or if the article and its labeling and other material required to be submitted do not comply with the provisions of this Act, he shall notify the applicant for registration of the manner in which the article, labeling or other material required to be submitted fail to comply with the Act so as to afford the applicant for registration an opportunity to make the corrections necessary. If, upon receipt of such notice, the applicant for registration does not make the corrections, the Secretary shall refuse to register the article. The Secretary, in accordance with the procedures specified herein, may suspend or cancel the registration of an economic poison whenever it does not appear that the article or its labeling or other material required to be submitted complies with the provisions of this Act. Whenever the Secretary refuses registration of an economic poison or determines that registration of an economic poison should be cancelled, he shall notify the applicant for registration or the registrant of his action and the reasons therefor. Whenever an application for registration is refused, the applicant, within thirty days after service of notice of such refusal, may file a petition requesting that the matter be referred to an advisory committee or file objections and request a public hearing in accordance with this section. A cancellation of registration shall be effective thirty days after service of the foregoing notice unless within such time the registrant (1) makes the necessary corrections; (2) files a petition requesting that the matter be referred to an advisory committee; or (3) files objections and requests a public hearing. Each advisory committee shall be composed of experts, qualified in the subject matter and of adequately diversified professional background selected by the National Academy of Sciences and shall include one or more representatives from land-grant colleges. The size of the committee shall be determined by the Secretary. Members of an advisory committee shall receive as compensation for their services a reasonable per diem, which the Secretary shall by rules and regulations prescribe, for time actually spent in the work of the

committee, and shall in addition be reimbursed for their necessary traveling and subsistence expenses while so serving away from their places of residence, all of which costs may be assessed against the petitioner, unless the committee shall recommend in favor of the petitioner or unless the matter was referred to the advisory committee by the Secretary. The members shall not be subject to any other provisions of law regarding the appointment and compensation of employees of the United States. The Secretary shall furnish the committee with adequate clerical and other assistance, and shall by rules and regulations prescribe the procedures to be followed by the committee. The Secretary shall forthwith submit to such committee the application for registration of the article and all relevant data before him. The petitioner, as well as representatives of the United States Department of Agriculture, shall have the right to consult with the advisory committee. As soon as practicable after such submission, but not later than sixty days thereafter, unless extended by the Secretary for an additional sixty days, the committee shall, after independent study of the data submitted by the Secretary and all other pertinent information available to it, submit a report and recommendation to the Secretary as to the registration of the article, together with all underlying data and a statement of the reasons or basis for the recommendations. After due consideration of the views of the committee and all other data before him, the Secretary shall within ninety days after receipt of the report and recommendations of the advisory committee, make his determination and issue an order, with findings of fact, with respect to registration of the article and notify the applicant for registration or registrant. The applicant for registration, or registrant, may within sixty days from the date of the order of the Secretary, file objections thereto and request a public hearing thereon. In the event a hearing is requested, the Secretary shall, after due notice, hold such public hearing for the purpose of receiving evidence relevant and material to the issues raised by such objections. Any report, recommendations, underlying data, and reasons certified to the Secretary by an advisory committee shall be made a part of the record of the hearing, if relevant and material, subject to the provisions of section 7(c) of the Administrative Procedure Act (5 U.S.C. 1006 (c)). The National Academy of Sciences shall designate a member of the advisory committee to appear and testify at any such hearing with respect to the report and recommendations of such committee upon request of the Secretary, the petitioner, or the officer conducting the hearing: *Provided*, That this shall not preclude any other member of the advisory committee from appearing and testifying at such hearing. As soon as practicable after completion of the hearing, but not later than ninety days, the Secretary shall evaluate the data and reports before him, act upon such objections and issue an order granting, denying, or cancelling the registration or requiring modification of the claims or the labeling. Such order shall be based only on substantial evidence of record of such hearing, including any report, recommendations, underlying data, and reason certified to the Secretary by an advisory committee, and shall set forth detailed findings of fact upon which the order is based. In connection with considerations of any registration or

29-H

application for registration under this section, the Secretary may consult with any other Federal agency or with an advisory committee appointed as herein provided. Notwithstanding the provisions of section 3.c. (4), information relative to formulas of products acquired by authority of this section may be revealed, when necessary under this section to an advisory committee or to any Federal agency consulted, or at a public hearing, or in findings of fact issued by the Secretary. All data submitted to an advisory committee in support of a petition under this section shall be considered confidential by such advisory committee: Provided, That this provision shall not be construed as prohibiting the use of such data by the committee in connection with its consultation with the petitioner or representatives of the United States Department of Agriculture, as provided for herein, and in connection with its report and recommendations to the Secretary. Notwithstanding any other provision of this section, the Secretary may, when he finds that such action is necessary to prevent an imminent hazard to the public, by order, suspend the registration of an economic poison immediately. In such case, he shall give the registrant prompt notice of such action and afford the registrant the opportunity to have the matter submitted to an advisory committee and for an expedited hearing under this section. Final orders of the Secretary under this section shall be subject to judicial review, in accordance with the provisions of subsection d. In no event shall registration of an article be construed as a defense for the commission of any offense prohibited under section 3 of this Act.

d. In a case of actual controversy as to the validity of any order under this section, any person who will be adversely affected by such order may obtain judicial review by filing in the United States court of Appeals for the circuit wherein such person resides or has his principal place of business, or in the United States Court of Appeals for the District of Columbia Circuit, within sixty days after the entry of such order, a petition praying that the order be set aside in whole or in part. A copy of the petition shall be forthwith transmitted by the clerk of the court to the Secretary, or any officer designed by him for that purpose, and thereupon the Secretary shall file in the court the record of the proceedings on which he based his order, as provided in section 2112 of title 28, United States Code. Upon the filing of such petition the court shall have exclusive jurisdiction to affirm or set aside the order complained of in whole or in part. The findings of the Secretary with respect to questions of fact shall be sustained if supported by substantial evidence when considered on the record as a whole, including any report and recommendations of an advisory committee. If application is made to the court for leave to adduce additional evidence, the court may order such additional evidence to be taken before the Secretary, and to be adduced upon the hearing in such manner and upon such terms and conditions as to the court may seem proper, if such evidence is material and there were reasonable grounds for failure to adduce such evidence in the proceedings below. The Secretary may modify his findings as to the facts and order by reason of the additional evidence so taken, and shall file with the court such modified findings and order. The

judgment of the court affirming or setting aside, in whole or in part, any order under this section shall be final, subject to review by the Supreme Court of the United States Code. The commencement of proceedings under this section shall not, unless specifically ordered by the court to the contrary, operate as a stay of an order. The court shall advance on the docket and expedite that disposition of all causes filed therein pursuant to this section.

e. Notwithstanding any other provisions of this Act, registration is not required in the case of an economic poison shipped from one plant to another plant operated by the same person and used solely at such plant as a constituent part to make an economic poison which is registered under this Act.

f. The Secretary is authorized to cancel the registration of any economic poison at the end of a period of five years following the registration of such economic poison or at the end of any five-year period thereafter, unless the registrant, prior to the expiration of each such five-year period, requests in accordance with regulations issued by the Secretary that such registration be continued in effect.

Books and Records

Sec. 5. For the purposes of enforcing the provisions of this Act, any manufacturer, distributor, carrier, dealer, or any other person who sells or offers for sale, delivers, or offers for delivery, or who receives or holds any economic poison or device subject to this Act, shall, upon request of any employee of the United States Department of Agriculture or any employee of any State, Territory, or political subdivision, duly designated by the Secretary, furnish or permit such person at all reasonable times to have access to, and to copy all records showing the delivery, movement, or holding of such economic poison or device, including the quantity, the date of shipment and receipt, and the name of the consignor and consignee; and in the event of the inability of any person to produce records containing such information, all other records and information relating to such delivery, movement, or holding of the economic poison or device. Notwithstanding this provision, however, the specific evidence obtained under this section shall not be used in a criminal prosecution of the person from whom obtained.

Enforcement

Sec. 6. a. The Secretary (except as otherwise provided in this section) is authorized to make rules and regulations for carrying out the provisions of this Act, including the collection and examination of samples of economic poisons and devices subject to this Act and the determination and establishment of suitable names to be used in the ingredient statement. The Secretary is in addition, authorized after opportunity for hearing—

- (1) to declare a pest any form of plant or animal life or virus which is injurious to plants, man, domestic animals, articles, or substances;
- (2) to determine economic poisons, and quantities of substances contained in economic poisons, which are highly toxic to man; and

30-H

(3) to determine standards of coloring or discoloring for economic poisons, and to subject economic poisons to the requirements of section 3.a. (4) of this Act.

b. The Secretary of the Treasury and the Secretary of Agriculture shall jointly prescribe the regulations for the enforcement of section 10 of this Act.

c. The examination of economic poisons or devices shall be made in the United States Department of Agriculture or elsewhere as the Secretary may designate for the purpose of determining from such examination whether they comply with the requirements of this Act, and if it shall appear from any such examination that they fail to comply with the requirements of this Act, the Secretary shall cause notice to be given to the person against whom criminal proceedings are contemplated. Any person so notified shall be given an opportunity to present his views, either orally or in writing, with regard to such contemplated proceedings, and if in the opinion of the Secretary it appears that the provisions of this Act have been violated by such person, then the Secretary shall certify the facts to the proper United States attorney, with a copy of the results of the analysis of the examination of such article: *Provided*, That nothing in this Act shall be construed as requiring the Secretary to report for prosecution or for the institution of libel proceedings minor violations of this Act whenever he believes that the public interest will be adequately served by a suitable written notice of warning.

d. It shall be the duty of each United States attorney, to whom the Secretary or his agents shall report any violation of this Act, to cause appropriate proceedings to be commenced and prosecuted in the proper courts of the United States without delay.

e. The Secretary shall, by publication in such manner as he may prescribe, give notice of all judgments entered in actions instituted under the authority of this Act.

Exemptions

Sec. 7. a. The penalties provided for a violation of section 3.a. of this Act shall not apply to—

- (1) any person who establishes a guaranty signed by, and containing the name and address of, the registrant or person residing in the United States from whom he purchased and received in good faith the article in the same unbroken package, to the effect that the article was lawfully registered at the time of sale and delivery to him, and that it complies with the other requirements of this Act, designating this Act. In such case the guarantor shall be subject to the penalties which would otherwise attach to the person holding the guaranty under the provision of this Act;
- (2) any carrier while lawfully engaged in transporting an economic poison or device if such carrier upon request by a person duly designated by the Secretary shall permit such person to copy all records showing the transactions in and movement of the articles;
- (3) to public officials while engaged in the performance of their official duties;

(4) to the manufacturer or shipper of an economic poison for experimental use only by or under the supervision of any Federal or State agency authorized by law to conduct research in the field of economic poisons; or by others if a permit has been obtained before shipment in accordance with regulations promulgated by the Secretary.

Penalties

Sec. 8. a. Any person violating section 3.a. (1) of this Act shall be guilty of a misdemeanor and shall on conviction be fined not more than \$1,000.

b. Any person violating any provision other than section 3.a. (1) of this Act shall be guilty of a misdemeanor and shall upon conviction be fined not more than \$500 for the first offense, and on conviction for each subsequent offense be fined not more than \$1,000 or imprisoned for not more than one year, or both such fine and imprisonment: *Provided*, That an offense committed more than five years after the last previous conviction shall be considered a first offense. An article the registration of which has been terminated may not again be registered unless the article, its labeling, and other material required to be submitted appear to the Secretary to comply with all the requirements of this Act.

c. Notwithstanding any other provision of this Section, in case any person with intent to defraud, uses or reveals information relative to formulas of products acquired under the authority of section 4 of this Act, he shall be fined not more than \$10,000 or imprisoned for not more than three years, or both such fine and imprisonment.

d. When construing and enforcing the provisions of this Act, the act, omission or failure, of any officer, agent, or other person acting for or employed by any person shall in every case be also deemed to be the act, omission, or failure of such person as well as that of the person employed.

Seizures

Sec. 9. a. Any economic poison or device that is being transported from one State, Territory, or District to another, or having been transported, remains unsold or in original unbroken packages, or that is sold or offered for sale in the District of Columbia or any Territory, or that is imported from a foreign country, shall be liable to be proceeded against in any district court of the United States in the district where it is found and seized for confiscation by a process of libel for condemnation—

(1) in the case of an economic poison—

(a) if it is adulterated or misbranded;

(b) if it is not registered pursuant to the provisions of section 4 of this Act;

(c) if it fails to bear on its label the information required by this Act;

(d) if it is a white powder, economic poison, and is not colored as required under this Act; or

(2) in the case of a device if it is misbranded.

b. If the article is condemned it shall, after entry of the decree, be disposed of by destruction or sale as the court may direct and the proceeds, if sold, less the legal costs, shall be paid into the Treasury of the United States, but the article shall not be sold contrary to the provisions of this

31-H

Act or of the laws of the jurisdiction in which it is sold; *Provided*, That upon the payments of the costs of the libel proceedings and the execution and delivery of a good and sufficient bond conditioned that the article shall not be sold or otherwise disposed of contrary to the provisions of this Act or the laws of any State, Territory, or District in which sold, the court may direct that such articles be delivered to the owner thereof. The proceedings of such libel cases shall conform, as near as may be, to the proceedings in admiralty, except that either party may demand trial by jury of any issue of fact joined in any case, and all such proceedings shall be at the suit of and in the name of the United States.

c. When a decree of condemnation is entered against the article, court costs and fees, storage, and other proper expenses shall be awarded against the person, if any, intervening as claimant of the article.

Imports

Sec. 10. The Secretary of the Treasury shall notify the Secretary of Agriculture of the arrival of economic poisons and devices offered for importation and shall deliver to the Secretary of Agriculture, upon his request, samples of economic poisons or devices which are being imported or offered for import into the United States, giving notice to the owner or consignee, who may appear before the Secretary of Agriculture and have the right to introduce testimony. If it appears from the examination of a sample that it is adulterated, or misbranded or otherwise violates the prohibitions set forth in this Act, or is otherwise dangerous to the health of the people of the United States, or is of a kind forbidden entry into or forbidden to be sold or restricted in sale in the country in which it is made or from which it is exported, the said article may be refused admission, and the Secretary of the Treasury shall refuse delivery to the consignee and shall cause the destruction of any goods refused delivery which shall not be exported by the consignee within three months from the date of notice of such refusal under such regulations as the Secretary of the Treasury may prescribe: *Provided*, That the Secretary of the Treasury may deliver to the consignee such goods pending examination and decision in the matter on execution of penal bond for the amount of the full invoice value of such goods, together with the duty thereon, and on refusal to return such goods for any cause to the custody of the Secretary of Treasury, when demanded, for the purpose of excluding them from the country, or for any other

purpose, said consignee shall forfeit the full amount of said bond: and provided further, That all charges for storage, cartage, and labor on goods which are refused admission or delivery shall be paid by the owner or consignee and in default of such payment shall constitute a lien against any future importation made by such owner or consignee.

Delegation of Duties

Sec. 11. All authority vested in the Secretary by virtue of the provisions of this Act may with like force and effect be executed by such employees of the United States Department of Agriculture as the Secretary may designate for the purpose.

Authorization for Appropriations and Expenditures

Sec. 12. a. There is hereby authorized to be appropriated, out of any moneys in the Treasury not otherwise appropriated, such sums as may be necessary for the purposes and administration of this Act. In order to carry out the provisions of this Act, which take effect prior to the repeal of the Insecticide Act of 1910, appropriations available for the enforcement of such Act are authorized to be made available.

b. The Secretary is authorized from the funds appropriated for this Act to make such expenditures as he deems necessary, including rents, travel supplies, books, samples, testing devices, furniture, equipment, and such other expenses as may be necessary to the administration of this Act.

Cooperation

Sec. 13. The Secretary is authorized to cooperate with any other department or agency of the Federal Government and with the official agricultural or other regulatory agency of any State, or any State, Territory, District, possession, or any political subdivision thereof, in carrying out the provisions of this Act, and in securing uniformity of regulations.

Separability

Sec. 14. If any provision of this Act is declared unconstitutional, or the applicability thereof to any person or circumstances is held invalid, the constitutionality of the remainder of this Act and the applicability thereof to other persons and circumstances shall not be affected thereby.

32-H

INTERDEPARTMENTAL AGREEMENTS ON PESTICIDES

(Interdepartmental Agreement for Protection of Public Health and Quality of Environment announced March 3, 1970, and establishment of a working group of the Subcommittee on Pesticides of the Cabinet Committee on the Environment announced March 26, 1970)

INTERDEPARTMENTAL AGREEMENT

Purpose. Coordination of the activities of the three Departments pertaining to economic poisons as defined in section 2 of the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135), hereinafter referred to as pesticides, with reference to the review of current or proposed registrations to assure maximum protection of the public health, the well being of man, and the quality of the environment.

Existing departmental responsibilities. Each of the three Departments has certain statutory authority and responsibility relating to pesticides in the environment, as set forth below:

Department of Agriculture

1. Statutory authority under the Federal Insecticide, Fungicide, and Rodenticide Act for registration of pesticides.

2. Responsibility for research, education, information, regulatory, and action programs designed to protect the well being of man, crops, livestock, forests, ranges, habitats, products, structures, and premises against arthropod and other invertebrate pests, weeds, and fungi with equal concern for the protection of beneficial nontarget organisms and the quality of the environment.

Department of Health, Education, and Welfare

DHEW has the statutory authority and responsibility under the Federal Food, Drug, and Cosmetic Act for establishing safe tolerances for pesticides in or on raw agricultural commodities, processed food and potable water. The Department also has responsibilities for protecting the public from health, occupational, and environmental hazards related to the use and disposal of pesticides, and for other public health aspects such as the control of diseases and their vectors.

Department of Interior

USDI has statutory authority and responsibility under the Federal Water Pollution Control Act to carry out programs, to protect and enhance the quality of the Nation's waters including determining the effects of pesticides in water on health, welfare, and aquatic life. These responsibilities include establishing water quality standards for interstate waters. The Department also has statutory

authority for the conservation of wild birds, fish, mammals, their food organisms and their environment as affected by pesticides and the appraisal of effects of pesticides on fish and wildlife.

Information. Each Department will keep each of the other Departments fully informed of developments in knowledge from research or other sources which may come into its possession in connection with matters referred to in this agreement. High priority shall be placed by each Department representative to respond to each of the other Departments' requests, whether written or oral, for any and all information concerning action pending or taken on pesticide matters.

Procedures -- A. General. 1. Each Department will designate a qualified representative to act on behalf of such Department in carrying out the terms of this agreement. All communications from USDA, DHEW, and USDI will be directed to these representatives.

2. USDA shall furnish to the other Departments copies of each proposal received for registration or reregistration with the accompanying safety data (if any) and a request for an opinion from DHEW and USDI on the requested action in their areas of responsibility.

3. Within 15 working days, DHEW and USDI shall evaluate each registration or reregistration proposal in light of the data supplied and offer an opinion or provide a status report as to whether or not the registration should be granted or specify the additional data deemed necessary before such evaluation can be made. When either is unable to assess the public health or environmental risk without additional data, USDA shall advise the registrant of its inability to consider registration of the pesticide until the additional data requested have been received and reviewed by the respective Departments according to the following procedures described below.

B. Specific. 1. The Departmental Representative will accomplish review by his agency of each proposal and report results of such review to each of the other agencies within 15 working days of the receipt of the proposal. If there is insufficient information to reach a decision of the proposal, USDA will be contacted within such period of 15 working days and advised with particularity what additional information is needed for the necessary evaluation. Applicants for registration should not be discouraged from communicating with DHEW or USDI on registration matters of mutual interest, so long as the other representatives

are informed of the details of such contact by memorandum thereof.

2. Upon receipt of such a request for further information, USDA will make arrangements to obtain the additional information, if available, and furnish it to the Department making the request. USDA will withhold final action on the matter for 15 working days, from the date of furnishing the requested information or advice that such information is not available, pending receipt of the report of the other Department of the results of further review.

3. If a Department concludes that the registration should be rejected in whole or in part, this view shall be expressed in writing along with a statement of the reasons for the conclusion including the specific information, lack of information, or scientific judgment upon which these are based.

Upon being so notified, USDA will notify the party involved, i.e., the applicant or registrant, and offer him an opportunity to submit any data, views or arguments with respect to the proposed rejection and any such submission shall be promptly referred to the other Department representatives who shall report to USDA the results of their review of the submission.

4. In the event that after the review of the additional data the Departments cannot agree on the approval of the proposal, any Department may request the formation of a Registration Review Panel for the purpose of making a complete review of the issues and related information or lack thereof and submit a detailed report of their findings. Each Registration Review Panel shall be composed of two representatives from each of the three Departments with the chairman to be selected from the representatives of the Department from which the objections have come.

The Registration Review Panel shall prepare its report within 20 working days, including any minority opinions, and submit it to each of the three Departments.

5. The report(s) of the Registration Review Panel shall be reviewed by each Department within 15 working days of its receipt.

6. If significant differences between the Departments remain still unresolved, all data and information submitted by all parties shall be reviewed at the first monthly Interdepartment Pesticide Meeting after the reviews of the Registration Review Panel reports have been made.

7. In the event agreement is not reached among the Department representatives at the monthly Interdepartment Pesticide Meeting, a submission of the reports of the reviews referred to in paragraphs B-1 through B-6 above, will be referred at the request of the Secretary of the objecting Department to the Cabinet Committee on Environmental Quality. The referral shall be accompanied by a statement prepared by each Department analyzing the issues involved and setting forth the decision it recommends. The Cabinet Committee on Environmental Quality will consider such recommendations and make a written report, either accepting, rejecting, or modifying them.

8. Based upon consideration of the action of the Cabinet Committee, the Secretary of Agriculture will make the decision as to the specific action to be taken with respect to the matter on which the Department representatives were not in agreement, and will thereupon notify the other two

Secretaries in writing in advance of the publication of the final determination if he has not followed the recommendations made by the objecting Department(s), specifically stating his reasons for such action.

9. When registration is granted, USDA shall supply to DHEW and USDI final printed labeling at the time of registration with a copy of the final letter to the registrant.

10. The Departmental representatives may review existing patterns of usage and registrations for particular pesticides. A conclusion by USDA, DHEW, or USDI that an existing pesticide use or registration may be detrimental to the public health or to the quality of the environment shall be transmitted to the other two Departments together with the supporting reasoning and information, with a recommendation for corrective action. Written information from all sources on the health or environmental aspects of such pesticides shall be submitted to a Registration Review Panel for review and recommendations. If USDA, DHEW, or USDI disagrees with the recommendations of the Registration Review Panel, that Department can initiate further review by the procedural steps described in paragraphs B-6 through B-8 above.

Interdepartment pesticide meetings and conferences. The Department representatives will meet jointly at an Interdepartment Pesticide Meeting once a month to provide a continuous dialogue concerning all aspects of their current activities and to promote cooperation and understanding among the Departments. Monthly reports concerning their activities will be made to the Secretaries of the three Departments, according to a mutually agreed upon format.

The Departmental representatives will arrange a general conference at least once each year to discuss research needs, research program and policy, and the application of research findings in action programs, including public information relating to pesticides. The Interdepartment Pesticide Conference will consider broad questions on policies relating to pesticides involving the interrelationships of control programs, research, registration, tolerances, the public health, and general departmental recommendations to the public.

In order to promote free interchange of information among the Departments involved under this agreement, each Department representative should be invited and encouraged to participate in conferences, meetings, and various symposiums with Federal, State, university, or industry people on possible matters of mutual interest.

Effective date and superseding. This agreement shall become effective upon signature by the Secretaries of USDA, USDI, and DHEW, and shall supersede the agreement entitled "Interdepartmental Coordination of Activities Relating to Pesticides by the Department of Agriculture, the Department of Health, Education, and Welfare, and the Department of the Interior," published in the FEDERAL REGISTER on May 1, 1964 (29 F.R. 5808).

CHARTER OF THE WORKING GROUP

A. *Establishment.* A working group of the Subcommittee on Pesticides of the Cabinet Committee on the Environment (formerly Environmental Quality Council) is established pursuant to action of the Committee (Council)

34-H

announced on November 20, and the Federal Committee on Pest Control is hereby abolished.

The working group will: (1) Provide day-to-day coordination of Federal agency pesticide activities; and (2) develop program and policy proposals for consideration by the Subcommittee on Pesticides.

The following agencies will have membership on the working groups:

Department of Agriculture.

Department of Health, Education, and Welfare.

Department of the Interior.

Department of Defense.

Department of Transportation.

Department of State.¹

The Office of Science and Technology, the Bureau of the Budget, and the Office of Intergovernmental Relations will be invited to designate an observer at the meetings of the working group. Other agencies will be invited to participate in meetings when matters of significant concern to them are to be discussed.

The working group will consist of one principal authorized to commit his agency in routine coordination and on most issues and to make reservations on behalf of his agency on controversial issues. At the request of any principal, Departmental or agency issues will be referred to the Subcommittee on Pesticides for review prior to implementation.

Each member agency will name one or more alternates to speak for that agency in the absence of the principal. Other individuals, cognizant of the pesticide programs and responsibilities of their agencies, may attend meetings to provide technical support for the principal.

It is recognized that the use of pesticide chemicals is necessary to protect man, animals, plants, and the environment against harmful insects, rodents, other vertebrate pests, weeds, and diseases. It is further recognized that use of pesticide chemicals, especially careless and unauthorized use, is hazardous to nontarget man, plants, and animals, and the environment. It is, therefore, essential that any use of a pesticide chemical be evaluated as to the necessity for its use, the harm which may result, and the precautions which must be taken to minimize harmful effects.

B. Purpose. The working group is the primary staff level coordinating mechanism for Federal activities concerning pesticides, pests, and their control. The activities coordinated by the working group include, but are not limited to:

(1) Pest control programs in various parts of the world in which there is active participation on the part of the Federal Government, either in funding or in supervision;

(2) Research on pests and their control and effects of control procedures, whether by chemical or other methods;

(3) Monitoring of the environment for pesticides and their residues;

(4) Establishment of pesticide investigation teams to conduct special investigations of pesticide problems which arise or which may be anticipated;

¹The intent is to assure adequate consideration of international concerns which are largely but not wholly represented within the Agency for International Development.

(5) Public information on pest control and the use of pesticides;

(6) Evaluation of economic and social values and risks involved in the control of pests by various methods; and

(7) Advice to the interdepartmental group on pesticide registration on problems that it believes should be considered by that group.

The working group shall advise the Subcommittee on Pesticides and the appropriate Federal departments and agencies concerning matters of common interest. In no case, however, will the working group supersede the responsibility of each department and agency to carry out the functions assigned to it by legislative and executive mandates. The working group will encourage exchange of information among international, Federal, State, and local agencies and may participate with them as appropriate.

C. Procedures - 1. Review of programs. a. On request, any Federal agency shall submit to the working group for review a detailed description of its proposed and current pest control programs and monitoring, research, education, and other programs pertaining to pest control.

b. The working group will review such programs from the standpoint of effectiveness, economic impact and hazards to human health, to livestock and crops, to fish or wildlife, and to other elements of the environment.

c. Based on such review, the working group shall recommend to the heads of the departments or agencies concerned such modifications in the programs as the working group feels will best serve the public interest.

2. Intergovernmental cooperation. a. The working group shall promote or encourage review of both Federal and non-Federal programs by State and local groups representing a broad spectrum of interests and responsibilities.

b. The working group may communicate with such State and local groups to receive their recommendations and to make recommendations to them either directly or through member departments, whichever seems most expeditious and effective.

c. Subject to foreign policy guidance from the Department of State, the working group may participate in joint activities with foreign or international groups having similar interests and will coordinate these activities among Federal and State agencies. Informal recommendations arising from such joint activities may be directed by the working group to the concerned Federal department or agency. No formal recommendations shall be transmitted directly to any foreign government or international agency.

3. Stimulation of new activities. a. Whenever the working group feels that the public interest will be served by the initiation of new activity, such as interdepartmental participation in integrating a variety of control methods or in analyzing jointly the efforts of such integrated control on all aspects of the environments, the working group may recommend appropriate action to the Subcommittee on Pesticides and to the concerned departments or agencies and representatives of States.

4. Mechanisms available to the working group. a. The working group may establish ad hoc groups or panels of specialists to assist in discharging the working group's

35-H

responsibilities. Membership on such ad hoc groups need not be limited to representatives of Federal departments.

b. The working group may request the appropriate agencies to provide special services, consultation, staff, facilities, publications, conferences, etc., as may facilitate the work of the working group. Expenditure of appropriated funds for such activities of the working group must be within the authority and area of responsibility of the contributing department or agency and must remain within its individual fiscal control, even though the technical supervision may be provided by the working group.

D. *Membership.* Membership and observer status on the working group is by appointment of principals and alternates by letter, to the Chairman of the Subcommittee on Pesticides, from the heads of agencies concerned. On invitation of the working group, a liaison representative may be similarly appointed by other Government agencies having an interest in problems related to pest control.

E. *Officers and staff.* 1. The officers of the working group shall be:
Chairman.
Vice Chairman.
Executive Secretary.

The Chairman and Vice Chairman shall be elected from among members of the working group.

2. The staff of the working group shall include such professional and other staff as may be required.

3. It shall be the duty of the Chairman to preside at all meetings and to assure compliance with the charter of the working group. He shall call meetings of the working group when he deems it necessary or on request of any member department. The Chairman shall exercise leadership in seeking timely interagency coordination on items of con-

cern to the working group. The Chairman shall communicate directly with the Chairman of the Subcommittee on Pesticides as needed.

4. In the absence of the Chairman, the Vice Chairman will perform the functions of the Chairman.

5. The Executive Secretary will be responsible for:

a. Preparation of agenda, notice of meetings, correspondence, coordination of administrative matters and representation of the working group as requested by the Chairman.

b. Preparation and recommendation to the working group of pertinent policies and plans to meet the working group requirements. To this end, the Executive Secretary may request the Chairman to appoint advisory and other ad hoc groups as required.

c. Maintenance of minutes, sufficient other records and accounts to provide an annual report of the working group activities for such distribution as recommended by the working group.

F. *Meetings.* 1. Meetings shall be held at the call of the Chairman, following coordination with members regarding time, place, and date.

2. Decisions of the working group usually shall be made at regular meetings where there is an opportunity for discussion and not by correspondence or telephone calls, except in rare cases of urgency.

3. Minutes of meetings shall consist of a record of important discussions and decisions of the working group, but need not be a verbatim record. Minutes shall be distributed to principals, alternates, and observers.

G. *Quorum.* A majority of the members of the working group shall constitute a quorum authorized to transact any business duty presented at any meeting of the working group.

the method of administration from the federal level is more clearly defined.

The key role seen here for all state Departments of Agriculture and Extension Services cannot be minimized. It is hoped that legislators from both the state and federal level can be encouraged to lend their support to auxiliary programs, such as the reporting of human and livestock injury resulting from pesticide use or misuse. Such support is not desired to further restrict pesticide use, but rather as an aid in identifying additional problem areas where the full educational and service resources of each state can be focused.

A copy of FIFRA is included for reference. Terms such as environment, imminent hazard, protect health and environment, substantial adverse effects on the environment are conspicuous by their absence in FIFRA. The inclusion of these words in H. R. 10729 tends to bring the problem into focus. H. R. 10729 appears to be, in the final analysis, the best compromise legislation at the present time. Provisions for classification and registration of pesticides and applicator certification, although treated as a burden by one segment of the community, are regarded as too lenient by another (for a copy of H. R. 10729 see Volume II).

Section 20, Research and Monitoring, and Section 23, State Cooperation and Training, are particularly attractive.

The provisions which specifically empower the Administrator to foster research in biologically integrated alternatives for pest control are deemed necessary to the success of such endeavors. Hopefully, parts of 20 (b) - The Administrator shall formulate and periodically revise (emphasis ours)...national plan for monitoring - will be implemented. The contractor believes that parts of the present plan are woefully inadequate, cumbersome, and ineffectual in assessing environmental contamination.

The provisions of Section 23 which specifically allow the Administrator to expend public funds in the implementation of expanded state programs, particularly those provisions which seek to encourage training of certified pesticide applicators, are viewed as necessary and desirable. The expenditure of public monies for such purposes is seen as ultimately benefiting all mankind and the total environment, not just the recipient.

Testing and Registration of New Pesticides

Section 3. Registration of pesticides appears to provide for sufficient information to allow the Administrator to make adequate judgments regarding new compounds. The provisions which allow a full description of tests performed, 3 (c) (1) (D), and the results thereof to the Administrator as he desires and 3 (c) (1), wherein the Administrator shall

publish guidelines specifying the kinds of information required in support of registration, are regarded as particularly important. The further provision that the Administrator shall make public all scientific information relating to the registration of any particular compound is viewed as an absolute necessity and long overdue (S 23(c)(2), p. 18, lines 4-9). Although the contractor is sympathetic with industry's mounting registration costs, it feels that the publication of full scientific information relating to any new pesticide must be made so that the at-large scientific community has an opportunity to assess its validity. The contractor had no desire to infringe on the manufacturers' confidential information, but felt that there were times when access to such information could have made a valuable contribution to the total assessment of pesticide effects on test organisms.

In the event that the provisions in Section 10, Protection of Trade Secrets and Other Information, shall come into conflict with the above, the Administrator should code such compounds and seek additional outside scientific judgment. The contractor does not believe that information relating to adequately chosen test animals (including a sufficient number of aquatic organisms) should qualify as trade secrets, or commercial or financial information.

As indicated previously, rural constituencies were overwhelmingly in favor of H. R. 10729. A synopsis of the congressional tally on H. R. 10729 is presented in Table 1-H a detailed record of individual votes on the total bill and three amendments is shown in Table 2-H. "No" votes were predominantly from urban areas and attempted contacts with these lawmakers failed to disclose the reason for such a vote.

State Laws

A wide variation in laws is seen in the five-state study area. It should be remembered that the existence of a law does not, of itself, insure that the provisions will be carried out.

Illinois

The State of Illinois appears to have reasonably sound laws on record. Short courses conducted by the University of Illinois to implement the provisions covering commercial applicators appear excellent in content, although they are not specified in the Act. The creation of an interagency committee on pesticides and a state environmental protection agency are seen as forward steps toward safer use of pesticides. The present law is not inconsistent with the proposed bill (H. R. 10729).

TABLE 1-H

SYNOPSIS OF
CONGRESSIONAL TALLY ON H.R. 10729

November 9, 1971

State		Vote	Remarks
Illinois			
	Voting Yes	12	(9D, 3R)
	No	3	(3D) All from City of Chicago
	Not Voting	8	
	Absent	1	
Iowa			
	Yes	5	(1D, 4R)
	No	1	(1D)
Kansas	Yes	5	(1D, 4R)
Minnesota			
	Yes	6	(2D, 4R)
	No	2	(2D) Both from metropolitan Area
Missouri			
	Yes	8	(7D, 1R)
	No	2	(2D) (1 from St. Louis) (1 rural area, 5th District)

TABLE 2-H

U. S. HOUSE OF REPRESENTATIVES

Consideration of "Federal Environmental Pesticide Control Act of 1971"
 (As taken from Congressional Record of November 9, 1971)

State	Congressman	Kyl's Amendment (Registration)	Dow's Amendment (Judicial Review)	Eckhardt's Amendment (Indemnities)	Entire Bill
Illinois	Ralph H. Metcalfe (D) 1st District - City of Chicago	Not voting	Not voting	Yes	No
	Abner J. Mikva (D) 2nd District - City of Chicago	Yes	Yes	Yes	No
	Morgan Francis Murphy (D) -- 3rd District - City of Chicago	Yes	Yes	Yes	Yes
	Edward J. Derwinski (R) -- 4th District - Cook County	Not voting	Not voting	Not voting	Not voting
	John C. Kluczynski (D) -- 5th District - City of Chicago	Yes	Yes	Yes	Yes
	George W. Collins (D) 6th District - City of Chicago	Yes	Yes	Yes	Yes
	Frank Annunzio (D) 7th District - City of Chicago	Yes	Yes	Yes	Yes
	Dan Rostenkowski (D) 8th District - City of Chicago	Yes	Yes	Yes	Yes
	Sidney R. Yates (D) 9th District - City of Chicago	Yes	Yes	Yes	No

TABLE 2-H
U. S. HOUSE OF REPRESENTATIVES
Consideration of "Federal Environmental Pesticide Control Act of 1971"
(As taken from Congressional Record of November 9, 1971)

State	Congressman	Kyl's Amendment (Registration)	Dow's Amendment (Judicial Review)	Eckhardt's Amendment (Indemnities)	Entire Bill
Illinois	Ralph H. Metcalfe (D) 1st District - City of Chicago	Not voting	Not voting	Yes	No
	Abner J. Mikva (D) 2nd District - City of Chicago	Yes	Yes	Yes	No
	Morgan Francis Murphy (D)--3rd District - City of Chicago	Yes	Yes	Yes	Yes
	Edward J. Derwinski (R)--4th District - Cook County	Not voting	Not voting	Not voting	Not voting
	John C. Mluczynski (D)--5th District - City of Chicago	Yes	Yes	Yes	Yes
	George W. Collins (D) 6th District - City of Chicago	Yes	Yes	Yes	Yes
	Frank Annunzio (D) 7th District - City of Chicago	Yes	Yes	Yes	Yes
	Dan Rostenkowski (D) 8th District - City of Chicago	Yes	Yes	Yes	Yes
	Sidney R. Yates (D) 9th District - City of Chicago	Yes	Yes	Yes	No

State	Congressman	Kyl's Amendment (Registration)	Dow's Amendment (Judicial Review)	Eckhardt's Amendment (Indemnities)	Entire Bill
Illinois (continued)	Harold R. Collier (R) 10th District - City of Chicago	Not voting	Not voting	Not voting	Not voting
	Roman C. Pucinski (D) 11th District - City of Chicago	Yes	Yes	Yes	Yes
	Robert McClory (R) 12th District	Not voting	Not voting	Not voting	Not voting
	Philip M. Crane (R) 13th District - Cook County	Not voting	Not voting	Not voting	Not voting
	John N. Erlenborn (R)--14th District	No	Yes	No	Yes
	Charlotte T. Reid (R)--15th District	Absent	Absent	Absent	Absent
	John B. Anderson (R)--16th District	No	No	No	Yes
	Leslie C. Arends (R) 17th District	Not voting	Not voting	Not voting	Not voting
	Robert H. Michel (R) 18th District	Not voting	Not voting	Not voting	Not voting
	Thomas F. Railsback (R)--19th District	Not voting	Not voting	Not voting	Not voting
	Paul Findley (R) 20th District	No	No	No	Yes
	Kenneth J. Gray (D) 21st District	No	No	No	Yes
	William L. Springer (R)--22nd District	Not voting	Not voting	Not voting	Not voting

State	Congressman	Kyl's Amendment (Registration)	Dow's Amendment (Judicial Review)	Eckhardt's Amendment (Indemnities)	Entire Bill
Illinois (continued)	George Edward Shipley (D)--23rd District	No	Yes	No	Yes
	Charles Melvin Price (D)--24th District	Yes	Yes	Yes	Yes
Iowa	Fred Schwengel (R) 1st District	Not voting	Not voting	Not voting	Not voting
	John C. Culver (D) 2nd District	Yes	Yes	Yes	No
	H. R. Gross (R) 3rd District	No	No	No	Yes
	John Henry Kyl (R) 4th District	No	No	No	Yes
	Neal Smith (D) 5th District	No	No	No	Yes
	Wiley Mayne (R) 6th District	No	No	No	Yes
	William J. Scherle (R) 7th District	No	No	No	Yes
Kansas	Keith G. Sebelius (R) 1st District	No	No	No	Yes
	William Robert Roy (D) 2nd District	No	No	No	Yes
	Larry Winn, Jr. (R) 3rd District	No	No	No	Yes
	Garner E. Shriver (R) 4th District	No	No	Yes	Yes
	Joe Skubitz (R) 5th District	No	No	No	Yes

State	Congressman	Kyl's Amendment (Registration)	Dow's Amendment (Judicial Review)	Eckhardt's Amendment (Indemnities)	Entire Bill
Minnesota	Albert Harold Quie (R) --1st District	No	Yes	No	Yes
	Ancher Nelsen (R) 2nd District	No	No	No	Yes
	Bill Frenzel (R) 3rd District	No	Yes	Yes	Yes
	Joseph E. Karth (D) 4th District	Yes	Yes	Yes	No
	Donald MacKay Fraser (D) --5th District	Yes	Yes	Yes	No
	John M. Zwach (R) 6th District	No	No	No	Yes
	Bob Selmer Bergland (D) --7th District	No	No	No	Yes
	John A. Blatnik (D) 8th District	No	Yes	Not voting	Yes
	William L. Clay (D) 1st District	Not voting	Not voting	Not voting	No
	James Wadsworth Symington (D) --2nd District	Yes	Yes	Yes	Yes
Missouri	Leonor Kretzer Sullivan (D) --3rd District	Yes	Yes	No	Yes
	William J. Randall (D) --4th District	No	No	No	Yes

It can be pointed out that many farmers and agents from this state feel that even though the applicator (as a corporate entity) is licensed, many of his workers are not and that damage could and did occur due to lack of precautions on this person's part. The provisions of the existing law are rather weak in this regard and the penalties for abuse are insignificant. Compliance with the Administration bill should insure more strict compliance with training and safety precautions through increased penalties and additional educational effort.

When asked about this issue, Congressman Findley was not available but his legislative assistant, Mr. Madson, answered for the Congressman. The Congressman had voted for H. R. 10729 but had voted against the amendments including the one which did pass to give states the authority on general use pesticides. Mr. Madson indicated that the Congressman felt the state authority amendment would contribute to a continued fractionation or diversity of regulation in the several states, and that a uniform and reasonable control on a national basis is needed.

With respect to inputs received by the Congressman since the action on the bill, the response from his district has been favorable to his having supported the legislation. Only a few letters have been against his position.

Prior to the action on the floor of the House, the Congressman had numerous inputs from individual farmers and others in his district, and in particular, from farmer organizations and farmers' cooperatives. Mr. Madson indicated that they have found the inputs from the FS Services, Inc., a three-state farm cooperative, particularly helpful.

Mr. Madson stressed that the bulk of the farmers and the organizations and farm cooperatives recognize the need to work within a regulatory framework as provided by the new legislation, in order to preclude more restrictive limitations on their use of agricultural chemicals. He stated that the farmers' cooperatives, in general, are gearing up to assist the farmers through educational means to qualify under any registration system that may result from the eventual legislation. The Congressman's office feels that this type of approach will be of direct assistance to more effective, safe, and economic use of agricultural chemicals. No suggestions were offered for companion state legislation.

A synopsis of Illinois laws is included on the following pages.

Iowa

The Pesticide Act of Iowa is a combined registration (use) and applications law. Licensing provisions need to

SYNOPSIS OF ILLINOIS LAWS

<u>Title</u>	Custom Application of Pesticides [Ill. Ann. St. (1966), ch. 5, s 87(d) (1) et <u>seq.</u>]
<u>Prohibited acts</u>	Unlawful to engage in custom application of pesticides unless licensed by the Director of the Department of Agriculture.
<u>Exemptions</u>	Structural pest control operators, fumigators, governmental bodies, tree experts, farmers, canning establishments, veterinarians in practice, farmer or grower apply- ing pesticides to not more than two neighbors land each year and general pest control operators (nuisance pests or disease vectors).
<u>Licensing</u>	
qualifications	Must possess "adequate knowledge" concerning proper use and application of pesticides.
application	Must contain information regarding applicants' qualifications and pro- posed operations and other informa- tion deemed necessary by the Director.
examination	Applicant required to "pass the examination."
fees	Annual license fee \$25.
issuance	If found qualified, applicant shall be issued license valid for one year from date of issue, renewable w/o examination if fee paid and valid bond in effect. Director may restrict licensee to the use of certain types of material or equip- ment. Director may revoke license for listed statutory reasons, but must provide administrative hearings and appeal procedures.

nonresidents

Required to pass the examination annually.

Financial
responsibility

"Reasonable performance bond" required, or a deposit of cash or collateral in lieu of bond.

Authority granted
to:

issue regulations	Yes.
enforce the act	Yes.
delegate duties	Yes.
restruct usage	Yes.
inspect property	Yes.
require records	Yes.
cooperate with others	Yes.
publish information	Yes.
conduct courses	Not specified in act.
regulate storage, transportation, or disposal of pesticides	Not specified in act.
require compliance with label	Not specified in act.
license equipment	Not specified in act.
subpoena persons or records	Not specified in act.
report losses	Not specified in act.
investigate damages	Not specified in act.

Pesticide board

Interagency Committee on Pesticides
[Ill. Ann. St. (1965), ch. 5, s
271 to 276]

"An act to create an interagency committee on pesticides to study, advise and recommend any needed legislation concerning pesticides, and to approve all proposed rules and regulations pertaining to the labeling, sale, use or application of pesticides." The Act creates a 7-man committee representing Departments of Agriculture, Conservation, Public Health, Public Works and Buildings, Natural History Survey, College of Agriculture, and Illinois Environmental Protection Agency whose duties are to: (1) review the sale and use of pesticides, (2) review governmental sponsored or directed pesticide programs, (3) consider hazards of pesticide use, (4) recommend pesticide legislation, (5) obtain the views of interested parties, (6) advise and approve all programs (except research) involving pesticides on State property, and (7) meet quarterly or at the call of the Chairman or any member and report annually to the Governor. "All proposed rules and regulations pertaining to the regulations or prohibitions of the sale, use or application of pesticides and labeling of pesticides shall be submitted to and approved by the committee before they are promulgated and made effective."

Definitions

- | | |
|----------------|---------------------------|
| 1. pesticide | 11. Director |
| 2. insecticide | 12. custom application of |
| 3. fungicide | pesticides |
| 4. Nematocide | 13. aircraft |
| 5. herbicide | 14. ground equipment |
| 6. insect | 15. structures |
| 7. fungus | |
| 8. Nematode | |
| 9. weed | |
| 10. person | |

Penalties

Violation of the Act is a misdemeanor subject to a fine of not more than \$200 for the first

offense, and not more than \$400 for each subsequent offense.

Relevant laws

Use and Application of 2, 4-D and Related Herbicides [Ill. Ann. St. (1966), ch. 5, s 87(a) (1) to 87 (a) (8)]

Provides that county boards, or 10 or more commercial fruit or vegetable producers, may petition the Director of Agriculture, who may, upon the finding of certain facts, restrict or prohibit the use of hormone-type herbicides in the area set out in the petition.

"Economic Poison Law"

[Ill. Ann. St. (1966), ch. 5, s 87 (c) (1) to 87 (c) (13)]

Requires the registration and labeling of economic poisons (exempts pesticides properly registered under the USDA-FIFRA).

"Pesticides Control Law"

[Ill. Ann. St. (1969), ch. 5, s 256 to 267]

The act authorizes the Director of the Department of Agriculture or the Director of the Department of Public Health to issue regulations relating to labeling, sale, use or application of pesticides, and when approved by the Interagency Committee on Pesticides, to restrict or prohibit the use and application of a pesticide.

Tree Experts

[Ill. Ann. St. (1967), ch. 5, s 163 et seq.]

The act requires examination, licensing and regulation of persons who diagnose, recommend treatment, or provide care for ornamental or shade trees.

"Pest Control Compact"

[Ill. Ann. St. (1968), ch. 5, s 281]

An act to provide financial assistance for timely and coordinated effort of neighborhood States in conducting effective pest control activities when the State is threatened by pest outbreaks (from within or without) of more than local concern. Provides for an "insurance fund" with contributions from members of the compact, from which funds can be withdrawn for financial support of pest control or eradication activities. Provides for a governing body and a formula by states for contribution to the insurance fund. Law becomes operative when enacted by 5 or more states.

"The Insect Pest and Plant Disease Act"[Ill. Ann. St. (1966), ch. 5, s 61 et seq.]

Primarily a nursery inspection and pest quarantine act. Amendments of 1969 authorize the Department of Agriculture to prohibit in quarantined areas farm practices favorable to the development of pests, and to require certain crop disposal practices or crop treatments to control or eradicate pests.

"Uniform Hazardous Substances Act of Illinois"

[Ill. Ann. St. (1959), ch. 111 1/2, s 251 to 266 (a)]

Relates to "household type" chemicals and exempts economic poisons registered under the USDA Federal Insecticide, Fungicide, and Rodenticide Act. [Historical note - An act to regulate the sale of Paris Green was approved April 22, 1907, and repealed in 1967].

"Environmental Protection Act"
[Ill. Ann. St. (1966), ch. 111 1/2,
s 1001 to 1051]

be strengthened although financial responsibility and penalties for misuse or violation are considerably more stringent than those in Illinois. Laws passed in 1971 strengthen the rules governing aerial application. Laws failing in 1971 would have materially strengthened the existing law, but would be covered to some extent in the Administration bill.

The institution of a chemical technology review board was regarded as a strong step forward. This board seemed fairly constituted and with the advice of the advisory committee, more than adequate to allow the Secretary of Agriculture to promulgate additional laws and regulations.

Authority granted to the board inter alia, to "adopt rules relating to the sale, use, and disuse of agricultural chemicals," has since been judged unconstitutional by the Iowa Supreme Court. This rather effectively reduces the power of the board. The vote for the Administration bill would suggest that such powers might be restored to the board when new state laws are formed in compliance with federal regulations.

The contractor was unable to contact legislators from Iowa for their views.

Kansas

Stringent financial responsibility marks the Kansas Pesticide Use Law. Provisions for a pesticide board

SYNOPSIS OF IOWA LAWS

<u>Title</u>	"Pesticide Act of Iowa" [Iowa Code Ann. (1969), s 206.1 to 206.12] Combination registration law and commercial applicators law.
<u>Prohibited acts</u>	Unlawful to engage in custom application of pesticides unless licensed by the Secretary of Agriculture.
<u>Exemptions</u>	Farmer trading work with another and State and Federal employees engaged in research.
<u>Licensing</u>	
qualification	Proof of competency and responsibility required.
application	"...properly executed application..." required.
examination	Written examination may be required.
fees	Initial fee \$10; renewal fee \$5.
issuance	An annual license, expiring October 31, shall be issued upon receipt of properly executed application and payment of fee. Secretary may refuse to renew license during a period of investigation of applicator's wrongdoing and may cancel license if applicator is convicted of a violation of the act. Aerial commercial applicators must also be registered with the Iowa Aeronautics Commission.
nonresidents	Licensing of a nonresident implies consent to the appointment of the Secretary of Agriculture as his agent for service of legal process.
<u>Financial responsibility</u>	Proof of unencumbered net financial worth of \$5,000, or surety bond of \$5,000, or liability insurance policy of \$5,000.

Authority granted
to:

issue regulations	Yes.
enforce the act	Yes.
delegate duties	Yes.
restrict usage	Secretary may ban pesticides in specific areas or during certain periods of time upon evidence of damage to crops or livestock and may determine "...proper use of pesticides..."
inspect property	Yes.
require records	Yes.
cooperate with others	Yes.
publish information	Not specified in act.
conduct courses	Not specified in act.
regulate storage, transportation, disposal of pesticides	Yes.
require compliance label	Not specified in act.
license equipment	Not specified in act.
subpoena persons or records	Not specified in act.
report losses	Not specified in act.
investigate damages	Not specified in act.

Pesticide board (Text at end of Iowa digest).

Definitions

- | | |
|--------------------------|----------------------------|
| 1. active ingredient | 8. ingredient statement |
| 2. adulterated | 9. label |
| 3. antidote | 10. labeling |
| 4. commercial applicator | 11. misbranded |
| 5. department | 12. person |
| 6. device | 13. pesticide |
| 7. inert ingredient | 14. plant growth regulator |
| | 15. registrant |
| | 16. Secretary |

Penalties

[Various] from \$100 to \$1,000 fine and imprisonment for up to one year.

Relevant laws

None.

LAWS PASSED IN

1971

Title

Amendment to "Pesticides Act of Iowa" House Bill No. 39.
Permits nonresident aerial applicator who is licensed in his home state to operate in Iowa.

Prohibited Acts

Unlawful to operate unless he works under the direct supervision of a person holding a valid Iowa aerial commercial applicator's license, or, unless he acquires an Iowa aerial applicator's license, posts bond in an amount determined by the Secretary of Agriculture, and registers with the Iowa Aeronautics Commission.

Authority Granted

To:

report losses Yes.

investigate damages

Yes, the losing party is required to pay the cost of the claims investigation.

Title

An Act Relating to the Authority of the Chemical Technology Review Board.
Senate File No. 326.
Amends the existing law to provide specifically that the Chemical Technology Review Board can restrict or prohibit the sale or use of any agricultural chemical, and provides for a public hearing on proposed regulations.

BILLS PROPOSED BUT NOT PASSED IN 1971

Title

House Bill No. 602.
Defines "restricted use pesticides" as any which the Secretary of Agriculture specifies and as injurious to anything other than the target pests.
Amends custom applicators law.

Title

Senate Bill No. 85 (House Bill No. 269)
Creates a Department of Environmental Quality with a Chemical Technology Committee with power to adopt rules on sale, use and disuse of pesticides.
Provides for registration of pesticides and for commercial applicator licensing.

PESTICIDE BOARD

[Iowa Code Ann. (1969), s 206A-1 to 206A-6]

A chemical technology review board has been established in the Department of Agriculture and consists of the Secretary of Agriculture, the Commissioner of Public Health, Director of the Iowa Natural Resources Council, Chairman of the State Soil Conservation Committee, Chief Executive of the League of Iowa Municipalities, State Conservation Director, Dean of the College of Agriculture of Iowa State University, a representative of a firm in Iowa actively engaged in the manufacture of formulation of agricultural chemicals, and a farmer experienced in the application of agricultural chemicals.

The board has authority, inter alia, to "adopt rules relating to the sale, use, and disuse of agricultural chemicals." (Agricultural chemicals are defined so as to include pesticides and fertilizers).

There is also an advisory committee to the chemical technology review board which consists of the Dean of the College of Veterinary Medicine, the Dean of the College of Medicine, an entomologist, botanist, geneticist and an agronomist all from Iowa State University, plus the technical secretaries of the Iowa Air Pollution Control Commission, and two ecologists. The advisory committee is charged with the responsibility of obtaining scientific data and recommending rules regarding control of agricultural chemicals.

CHEMICAL TECHNOLOGY REVIEW BOARD

Secretary of Agriculture

L. B. Liddy (or designee, Robert H. Lounsberry)

State Capitol

Des Moines, Iowa 50319

Phone: 515/281-5321

Commissioner of Public Health

Dr. Arnold Reeve

State Health Department

Lucas Building

Des Moines, Iowa 50319

Phone: 515/281-5605

Director of Iowa Natural Resources Council

Othie R. McMurry - Vice-Chairman

Natural Resources Council

Grimes Building

Des Moines, Iowa 50319

Phone: 515/281-5914

Chairman of State Soil Conservation

George Annan

Clarinda, Iowa 51632

Phone: 712/542-2451

or

Designee Fred Cherry

Rowley, Iowa - Chairman

Phone: 319/938-2721

Chief Executive of League of Iowa Municipalities

Robert E. Hays

444 Insurance Exchange Building

Des Moines, Iowa 50309

Phone 515/288-2119

Director of Iowa State Conservation Commission

Fred Priewert

Valley Bank Building

Des Moines, Iowa 50309

Phone: 515/281-5384

Dean, College of Agriculture, ISU of Science & Technology

Dr. Floyd Andre (or designee, Dr. S. A. Ewing)

123 Curtiss

Iowa State University

Ames, Iowa 50010

Phone 515/294-2518

Rep. of firm in Iowa actively engaged in manufacture
or formulation of agricultural chemicals appointed
by the Governor

Robert C. Yapp

2602 S.W. Caulder

Des Moines, Iowa 50321

Phone: 515/285/2829

Chevron Chemical Company

7524 Hickman Rd.

Des Moines, Iowa 50321

Phone 515/276-6726

Farmer experienced in application of agricultural
chemicals appointed by the Governor

Gordon E. Mau

R. R. #3

New Hampton, Iowa 50659

Phone: 515/394-3281

ADVISORY COMMITTEE
CHEMICAL TECHNOLOGY REVIEW BOARD

Dean, College of Veterinary Medicine, ISU represented by
Dr. William B. Buck
Professor of Veterinary Toxicology
Veterinary Diagnostic Laboratory
College of Veterinary Medicine
Iowa State University
Ames, Iowa 50010 Phone: 515/294-1950

Dean, College of Medicine, University of Iowa represented by
Dr. Keith R. Long - Vice Chairman
Dept. of Preventive Medicine & Environmental Health
University of Iowa
Iowa City, Iowa 52240 Phone: 319/353-3616

Appointed by Dean, College of Agriculture, ISU
Entomologist
Dr. Harold Gunderson
104 Insectary, ISU, Ames, Iowa 50010
Phone: 515/294-1101

Agronomist
Dr. Regis Voss
117 Agronomy, ISU, Ames, Iowa 50010
Phone: 515/294-1923

Botanist
Dr. David Staniforth - Chairman
457 Bessey, ISU, Ames, Iowa 50010
Phone: 515/294-3870

Geneticist
Dr. John D. Imsande
8 Curtiss, ISU, Ames, Iowa 50010
Phone: 515/294-3908

Technical Secretary, Iowa Air Pollution Control
Commission
Dr. Charles L. Campbell, Technical Secretary
State Department of Health
Lucas Building
Des Moines, Iowa 50319 Phone: 515/281-5345

Technical Secretary, Iowa Water Pollution Control
Commission

Mr. R. J. Schliekelman, Technical Secretary
State Department of Health
Lucas Building
Des Moines, Iowa 50319

Phone: 515/281-5345

Ecologist appointed by Dr. W. Robert Parks, Pres. of ISU

Dr. Larry D. Wing
62 Science
Iowa State University
Ames, Iowa 50010

Phone: 515/294-5176

Ecologist appointed by Dr. Willard Boyd, Pres. of U of I

Dr. Richard V. Bovbjerg
224 Zoology Building
University of Iowa
Iowa City, Iowa 52240

Phone: 319/353-3421

constructed similar to the Iowa law is viewed as a strong point. Kansas is the only one of the five states in which the Secretary is specifically required to issue regulations relating to the storage and discarding of pesticides or containers.

House Bill 1425, which did not pass in 1971, is seen as an outgrowth of revived efforts on the part of health officials in this state to identify and remedy the increasing number of human injuries reported over the past several years.

Although favored by all the congressmen from Kansas, H. R. 10729 is seen as something of an intrusion on the state's own pesticide law which two of the lawmakers see as effective for their needs.

When interviewed in Washington, Mr. Thompson, Legislative Assistant to Congressman Sebelius, indicated that the Congressman's office had put out no statement of views on the legislation since its passage, feeling that to do so would be premature until action on the legislation was taken by the Senate and the views of the two bodies resolved in a bill sent to the President for signature. He stated that the Congressman felt the most critical feature, in terms of how states should structure their legislation to coordinate with the Federal, would depend on the method used by the Federal agency in administering the legislation.

Mr. Thompson indicated that the views reflected by constituents of the First District of Kansas were consistently to minimize the degree of federal intervention into local activities. He stated that the farmers and their organized groups recognize the need to provide sufficient regulation, so that adverse actions by environmental groups would not preclude the availability of pesticides. He stressed the intention of the House Agriculture Committee to promote effective education efforts by farm extension agents to ensure adequate preparation of farmers desiring to qualify for the use of pesticides under the applicator regulation provisions of the legislation. He stated that the Congressman felt there is a well established and effective means of such education through the extension service and that this would go a long way in preventing misuse of pesticides through carelessness or ignorance. He foresaw concurrent benefits in the more economic use of pesticides.

Mr. Cooper, Legislative Assistant to Congressman Skubitz, indicated that the Congressman's mail, in general, had been very light on the subject of the pesticide control legislation. Most of the letters were from such groups as women's garden clubs who were strongly in favor of passage of H. R. 10729. Mr. Cooper did not respond to any effort to get an explanation of the Congressman's negative vote on the amendment to provide state authority over and beyond that which might be imposed by EPA. He indicated, however, the

general feeling that Kansas has had a strong and effective regulation of pesticides. He indicated a general favoring of national standards on labeling and felt that the State of Kansas could work within the legislation if the Senate version were essentially that of H. R. 10729.

Minnesota

Minnesota's Spraying and Dusting Law was the first law in the five-state study area to employ restricted use pesticide classification. DDT and its metabolites and the cyclodienes were severely restricted as of July, 1970. Congressman Bergland's comments on the possible disadvantage Minnesota farmers may have felt under such restricted use were of particular interest and are included in their entirety, as they show a rather complete grasp of the entire environmental question - the total view possessed by many lawmakers.

In total view, Minnesota already has more stringent control than most states and compares favorably with the Administration bill. No difficulty is seen in field implementation of that legislation.

It should be admitted that Minnesota does not have the same degree of agricultural involvement, as say, Iowa or Illinois, as far as corn and soybeans are concerned. This

SYNOPSIS OF KANSAS LAWS

<u>Title</u>	"Kansas Pesticide Use Law" [1970 Session Laws of Kansas, Chapt. 2]
<u>Prohibited acts</u>	Unlawful to engage in the business of applying pesticides to the land of another unless licensed by the Secretary of the State Board of Agriculture
<u>Exemptions</u>	Structural pest control operators, persons working on own premises or those of another in an exchange of work, shade tree and ornamental shrub work, and Government research personnel
<u>Licensing</u>	
qualifications	Must possess adequate knowledge concerning proper use and application of pesticides.
application	Must be in writing to the Secretary on a designated form furnished by the Secretary's office.
examination	Type not specified, but a number of subjects are included in the examination.
fees	Pesticide business applicator \$10; pesticide equipment operator \$10; public equipment operator \$10; business license \$25; government agency registration \$25; each unit of equipment \$10.
issuance	Issued upon being found qualified, and filing of bond or insurance; licenses expire at end of calendar year in which issued.
nonresidents	Must file written consent to accept service of legal process and to be sued for damages in Kansas courts.

Preceding page blank

Financial
responsibility

Aggregate amount of liability insurance to be not less than \$25,000. First unit of equipment shall carry \$8,000 liability insurance; additional units to carry \$2,000.

Authority granted
to:

issue regulations	Yes.
enforce the act	Yes.
delegate duties	Yes.
restrict usage	Yes; additionally county commissioners may restrict pesticides in their county if such restrictions are approved by the Secretary of Agriculture.
inspect property	Yes.
require records	Yes.
cooperate with others	Yes
publish information	Yes.
conduct courses	Not specified in act.
regulate storage	The Secretary "shall" issue regulations governing discarding and storing pesticides or pesticide containers.
require compliance with label	Implied.
license equipment	Yes.
subpoena persons or records	Yes.
report losses	Yes.
investigate damages	Yes.

Pesticide board

Thirteen-member board representing (1) health, (2) water resources, (3) forestry, fish and game, (4) geological survey, (5) agriculture, (6) soil conservation, (7) livestock commission, (8) House of Representatives, (9) Senate, (10) custom ground applicator, (11) custom aerial applicator, (12) pesticide industry, and (13) an agricultural user of pesticide. The board is advisory in nature and has no regulatory authority.

Definitions

- | | |
|---------------|-------------------------|
| 1. board | 12. pesticide business |
| 2. defoliant | applicator |
| 3. desiccant | 13. pesticide equipment |
| 4. equipment | operator |
| 5. fungus | 14. pesticide public |
| 6. insect | operator |
| 7. land | 15. plant regulator |
| 8. nematode | 16. rodent |
| 9. person | 17. Secretary |
| 10. pest | 18. snails or slugs |
| 11. pesticide | 19. weed |

Penalties

Violation of the act or regulations is an unclassified misdemeanor, subject to a fine of not less than \$100 and not more than \$500.

Relevant laws

"Kansas Pest Control Act"

[Kan. Stat. Ann. (1964), s 2-2401 et seq.]

Licenses and regulates:

1. termite control
2. structural insect control
3. fumigation, and
4. tree pest control

"Kansas Agricultural Chemical Act of 1947"

[Kan. Stat. Ann. (1964), s 2-2001 et seq.]

"Kansas Food, Drug, and Cosmetic Act"

[Kan. Stat. Ann. (1964), s 65-619 et seq.]

Hazardous Household Articles

[Kan. Stat. Ann. (1964), s 65-2701 et seq.]

LAWS PASSED IN 1971

Title

House Bill 1523

Exemptions

Those persons who apply pesticide to shade trees and ornamental shrubs, if they are licensed under Pest Control Act as pest control operators, are exempt from custom applicator's license requirement.

Title

House Bill 1524

Exemptions

Persons who apply pesticides to shade trees and ornamental shrubs if they are licensed under the Pesticide Use Law are exempt from Pest Control Act licensing requirement.

Title

House Bill 1622

Postpones effective date of Pesticide Use Law from January 1, 1972 to January 1, 1973.

BILLS PROPOSED BUT NOT PASSED

Title

House Bill 1425

Licensing conditions

sale, purchase and use by permit only

Authority granted to:

Secretary of Health

restrict usage Yes.

require records Yes.

publish information Yes.

state is richly endowed with natural waters and as a consequence is quite sensitive to the preservation of this resource. In a sense they can "afford" to be more restrictive in their thinking than the other states mentioned.

Congressman Bergland is a member of the House Agriculture Committee which developed H. R. 10729. He indicated that he saw the pesticide control legislation as a part of the overall effort in pollution control. The states have repeatedly urged Congress to act on minimum federal standards in all areas of pollution control. One of the viewed objectives of such action is to avoid the situation where an industry or comparable group takes advantage of the differences in state regulatory control to gain special concessions under the threat of moving their activities and the economic benefits thereof to a state with less strict regulations.

Mr. Bergland did not feel that the farmers of Minnesota have been at any disadvantage to farmers from other states because of the restrictions on the use of certain pesticides. He stated that the contacts he has had with farmers and farm organizations have at no time indicated such a disadvantage. The general tenor of comments from his home district during the period when the legislation was under consideration was favorable to passage. The only comments he has received since he voted for the bill have been from individuals who

expressed the view that legislation along the line of H. R. 10729 has been long overdue.

The Congressman continually stressed the relationship of this legislation to the total pollution control effort. He used as an example the provision for indemnification of those holding stocks of a pesticide that has been subsequently banned from use by the EPA Administrator. As he put it, without indemnification the holder of such unusable supplies would undoubtedly take the cheapest means of disposing of this excess stock. The result might well be indiscriminate dumping into an adjacent water course or disposal within a city dump with the potential for seriously contaminating both subsurface waters and surface waters by virtue of run-off. To qualify for the indemnification the holder of the pesticides stocks will need to return them to a designated point where EPA will be able to dispose of them without hazard to the environment.

The Congressman also stressed the efforts to avoid arbitrary or capricious action on the part of the Administrator. One specific example cited was the retention of the requirement for scientific review to a panel of the National Academy of Science. He favored the retention of this provision as a protection equally for the Administrator in documenting the background of his decisions and for the public in ensuring careful evaluation of the scientific

basis for any action with respect to pesticides.

Mr. Bergland saw no interference in the role of state agencies. He indicated that with the exception of one or two states, all states have some organization for pesticide control and viewed these as being a part of the total state pollution control effort. He stressed the role of the Department of Agriculture and the commitment of the Department to an extensive effort by the extension service in connection with the certification of private applicators as well as commercial applicators. He views the network of Federal, state, and county agricultural extension agents as a major resource in educating the users of pesticides to such practices as will provide for the concurrent accomplishment of improved agricultural production and protection of the environment. He stressed the need for more research on alternate means of control of agricultural pests through the research efforts of the Department of Agriculture. In commenting on the declining research efforts of pesticide manufacturers, he defended the provision for protecting the research data submitted by a pesticide manufacturer in connection with a registration application. He pointed out that under a pattern of limiting use of pesticides the opportunity of the manufacturer to recover his research and development costs is diminishing and cannot stand the competition of small manufacturers utilizing data which

SYNOPSIS OF MINNESOTA LAWS

<u>Title</u>	Minnesota Spraying and Dusting Law [Minn. Stat. (1969), s 18.031 to 18.036]
<u>Prohibited acts</u>	Unlawful to spray or dust for hire unless licensed by the Commissioner of Agriculture.
<u>Exemptions</u>	Homeowners and farmers on own pre- mises, or on neighbors' premises when not for hire.
<u>Licensing</u>	
qualifications	Determined by Commissioner to be "qualified."
application	To be made on form provided by Commissioner.
examination	Written.
fees	Original license or renewal \$5; each machine \$2.
issuance	Issued annually on calendar year basis, renewable by examination or by evidence of having completed approved training.
nonresidents	No provision for reciprocity.
<u>Financial responsibility</u>	Not specified in act.
<u>Authority granted to:</u>	
issue regulations	Yes.
enforce the act	Yes.
delegate duties	Yes.

restrict usage	Yes.
inspect property	Not specified in act.
require records	Yes.
cooperate with others	Not specified in act.
publish information	Not specified in act.
conduct courses	Not specified in act.
regulate storage, transportation, or disposal of pesticides	Yes.
require compliance with label	Yes.
license equipment	Not specified in act.
subpoena persons or records	Not specified in act.
report losses	Not specified in act.
investigate damages	Not specified in act.
<u>Pesticide board</u>	None.
<u>Definitions</u>	1. act 2. aerial applicator 3. aircraft 4. application 5. application and use 6. applicator 7. approved agency 8. authorized agent 9. commissioner 10. custom spraying or dusting 11. dealer's permit 12. device 13. economic poison 14. equipment 15. license 16. permit

Definitions

17. person
18. pest
19. pesticide
20. pollution
21. registered approved use
22. restricted use
23. spraying or dusting
operations for hire
24. users permit

Penalties

Violation of the act is a misdemeanor.

Relevant laws

Minnesota Economic Poisons and
Devices Law [Minn. Stat. (1969), s
24.069 to 24.077]

Structural Pest Control
[Minn. Stat. (1969), s 18A.01 to
18A.11]

Interstate Pest Control Compact
[Minn. Stat. (1969), s 18.62 to
18.71]

"Hazardous Substances Labeling
Act" [Minn. Stat. (1969), s
24.32 to 24.42]

BILLS PASSED IN 1971

<u>Title</u>	Senate Bill No. 624
<u>Licensing</u>	
examination	Yes.
fees	Registration fee of \$7.00.
issuance	Upon examination. Custom applicators must have license endorsed to apply pesticides to waste. Requires identification card for custom applicators and licensing of dealers of restricted use pesticides.
<u>Authority granted to:</u>	
enforce the act	Yes.
delegate duties	Yes.
inspect property	Yes.
require records	Yes.
<u>Title</u>	House Resolution 1-Y.
administration	Provides for supervision of standing committees during interim between regular sessions and that permissible studies may include "Economic Poisons," "Pollution Control Agency Role as it Relates to Agricultural Practices," and "Monitoring and Enforcement of Pollution Standards."

BILLS PROPOSED BUT NOT PASSED

<u>Title</u>	House Bill No. 163 (Senate Bill No. 1938).
<u>Prohibited acts</u>	Bans sale or use of mercury, DDT, aldrin, heptachlor, endrin, dieldrin, lindane and DDE (any any other pesticide viewed as environmentally harmful in opinion of the Board of Health) except under permit in extreme emergency.
<u>Title</u>	House Bill No. 365 (Senate Bill No. 1772).
<u>Prohibited acts</u>	Bans sale or use of pesticides in cities unless approved by Commissioner of Agriculture.
<u>Title</u>	House Bill No. 606 (Senate Bill No. 624).
<u>Provisions</u>	Enacts AAPCO Model Pesticide Use and Application Act with modifications. Adds dealer licensing provision.
<u>Title</u>	House Bill No. 14X
<u>Provisions</u>	Sale or use of pesticides containing mercury or DDT would be misdemeanor except for extreme emergency authorized by environmental pesticide review committee created by the bill. Committee may add other pesticides to the restricted list.
<u>Title</u>	Senate Bill No. 650 (House Bill No. 927)
<u>Prohibited Acts</u>	Bans use of chemical pesticides or defoliants by public service corporations on rights-of-way.

they did not themselves develop to register and produce the new pesticide. During the interview the Congressman also turned attention to other aspects of pollution control of impact on his farm constituency. These included the problems of run-off from feed lots, the investment required by dairy farmers in controlling discharge of wastes from their dairy barns, and the increasing problem that the State of Minnesota is having with the eutrophication of its many valuable lakes.

Missouri

Missouri holds the distinction of having the weakest of the state laws. Two bills introduced in 1971 were fought strenuously by dealers and manufacturers. At first, public hearings were held and testimony received. Finally the manufacturers and applicators acquiesced, reportedly feeling they could live with the House committee substitute for 315 and 571. Biologists and environmentalists were also satisfied. However, when brought to a vote, the bill failed to pass and both sides appeared to be surprised. At a special session (November 18, 1971) it was decided that proponents of the bill(s) would wait and see what happened to the Administration bill in the Senate (H. R. 10729). Thus, Missouri is left with the old economic poison law of 1955, as revised in 1969. It does specify that pesticides

be registered and provides for understandable labeling, packages, transport and sale.

The contractor, in its search for information in the five states, was impressed by the relationship between no law or an ineffective pesticide law and some other factors. For example, all states responded with lists of registered commercial applicators when asked, except Missouri, which apparently does not even have such a list. Missouri farmers of the five states appeared to be the most uninformed about pesticide use, and investigations indicated that some of the most flagrant violations of use, including container disposal, tank flushing, etc., occurred in Missouri. In addition to this general picture, examples of unlicensed operators who utilized unbranded bags of "material" were related to more frequently from Missouri.

The House Committee Substitute Bill is based on the AAPCO Model Bill; thus it would appear to have little problems of passage with needed revision if the Administration bill (H. R. 10729) is passed by the Senate.

Effects of Laws on Environmental Quality

The following Notice to Manufacturers, Formulators, Distributors and Registrants of Economic Poisons of Cancellation of Registration Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of Products Containing

MISSOURI

Title (No pesticide use and application law)

Relevant laws "Missouri Economic Poison Law of 1955" [Mo. Rev. Stat. (1969), s 263.270 to 263.380]

BILLS PROPOSED BUT NOT PASSED, 1971

Title House Bill No. 315

enacts AAPCO Model Pesticide Use and Application Act including restricted use/permit section; adds dealer licensing provision.

Title House Bill No. 571

prevents Undesirable effects from pesticide which degrade environment and are a menace to health, safety and welfare.

power to regulate Yes.

power to register Yes, after hearing to determine potential degradation of environment.

to restrict/prohibit use Yes.

to license Yes.

Title House Committee Substitute Bill for House Bill No. 315 and House Bill No. 571.

enacts AAPCO Model Pesticide Use and Application Act with Modifications.

power to regulate Yes. Use and sale in the public interest.

grants authority
to:

Commissioner of Agriculture to regulate handling, transportation, storage, disposal, display, and distribution of pesticides and containers and to regulate type of containers. Includes restricted use/permit, dealer licensing and stop sale provisions.

DDT, dated January 15, 1971 (reprinted on the following pages) and the accompanying statement of reasons underlying the registration decisions are presented in their entirety since these decisions represent the result of several court decisions, volumes of scientific testimony, public hearings, etc. Initiation of the administrative process whenever there is a substantial question about the safety of a registered pesticide is the key to control under the old FIFRA. Such a substantial question concerning the safety of DDT was raised and the subsequent action taken. It should be noted that many lawmakers view this provision of FIFRA as sufficient and, as a result, were not willing to vote for the current Administration bill, feeling that its additional restrictions were unwarranted. In any event the contractor views the current Administration bill as far less cumbersome and totally a more workable instrument for environmental protection under present conditions.

The recent decision (December 12, 1971) that DDT may be used only in interstate or export markets is viewed by the contractor as a wise administrative decision. On a number of occasions we were informed of abuses in local formulation or repackaging of DDT-containing products which were then used entirely within that state and since the state had no adequate laws for registration, a potentially harmful product was given free use.

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20250

Pesticides Regulation Division

PR Notice 71-1

January 15, 1971

NOTICE TO MANUFACTURERS, FORMULATORS, DISTRIBUTORS
AND REGISTRANTS OF ECONOMIC POISONS

Attention: Person Responsible For Federal Registration
of Economic Poisons

Cancellation of Registration Under the Federal
Insecticide, Fungicide, and Rodenticide Act of Products
Containing DDT

The insecticide DDT has been used extensively in the control of agricultural pests and insect vectors of diseases. The continued widespread use and the relatively slow rate of dissipation have resulted in contamination of the environment with low levels of DDT. Residues of this chemical are widespread in the environment and can be detected in areas far removed from sites of any known application. Although the levels of DDT in the environment are in most cases relatively low, they have been of concern to the scientific community for several years.

Recognizing the importance of this issue, the Department of Agriculture took steps to restrict the uses of DDT. These included the cancellation of registration for certain DDT products, and the publication of a notice in the Federal Register on November 25, 1969, proposing to eliminate other uses at a future date. This notice afforded interested persons an opportunity for a period of 90 days to submit views and comments. After consideration of the comments received, additional cancellation actions were taken in August 1970.

On December 2, 1970, the functions of the Secretary of Agriculture and the Department of Agriculture under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) were transferred to the Administrator of the Environmental Protection Agency. Since that date, this Agency has been reviewing previous actions and recommendations relating to the use of DDT, together with the relevant information available to the Agency. It has been our intention to issue at the earliest possible date a notice covering all of the remaining uses of DDT.

On January 7, 1971, the United States Court of Appeals for the District of Columbia Circuit in the case of Environmental Defense Fund, et al. v. William D. Ruckelshaus, Administrator of the Environmental Protection Agency, et al., held that the FIFRA requires

the Secretary "to issue notices and thereby initiate the administrative process whenever there is a substantial question about the safety of a registered pesticide." The Court further stated that "when, as in this case, he reaches the conclusion that there is a substantial question about the safety of a registered item, he is obliged to initiate the statutory procedure. . . ." The Court found that the statement of the Secretary of Agriculture filed in the case "makes it plain that he found a substantial question concerning the safety of DDT. . . ." The Court then ordered that the Administrator issue notices of cancellation of registration with respect to the remaining uses of DDT, and thereby commence the administrative process.

In view of the above, and in accordance with the provisions of Section 4c of the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135b(c)), it has been determined that all registrations of DDT products should be canceled for the reason that continued registration of these products is contrary to the provisions of Sections 2z(2)(c), 2z(2)(d), and 2z(2)(g) of the Act (7 U.S.C. 135(z)(2)(c), 135(z)(2)(d), 135z(2)(g)). Accordingly, you are hereby notified that the registrations of all products containing DDT not heretofore the subject of a cancellation notice are canceled, effective 30 days following receipt of this notice, unless the procedures set forth in Section 4c of the Act are invoked.


Lowell E. Miller
Acting Director

Environmental Protection Agency

REASONS UNDERLYING THE
REGISTRATION DECISIONS
CONCERNING PRODUCTS CONTAINING
DDT, 2,4,5-T, ALDRIN AND DIELDRIN

March 18, 1971

INTRODUCTION

Reorganization Plan No. 3 of 1970 transferred to the Environmental Protection Agency the principal responsibility for Federal regulation of "economic poisons" -- a term which includes those chemical substances which are commonly called pesticides. This regulation is conducted under (1) the Federal Insecticide, Fungicide and Rodenticide Act (7 U.S.C. §§ 135-135k) ("FIFRA") which requires registration of all pesticides introduced into interstate commerce, and (2) §§ 406, 408 and 409 of the Food, Drug and Cosmetic Act (21 U.S.C. §§ 346, 346a and 348), which provides for the establishment of maximum tolerances for residues of such economic poisons in or on food.

Under these provisions, this Agency is required initially to pass upon requests from manufacturers for registration of new economic poisons to determine whether they meet a variety of statutory requirements concerning safety and efficacy. The Agency must also review continuously previously registered economic poisons in order to insure continued compliance with these requirements in the light of the developing scientific data and concern for the public health. If this continuing review raises any substantial questions of safety, notices of cancellation must be issued which initiate the administrative process of review. If the threat is so immediate that it cannot await the resolution of this administrative process, registration of the pesticide must be suspended. At the conclusion of the administrative process, a final order with respect to registration is issued. In addition, a vigorous research and monitoring program is contemporaneously required to review the knowledge necessary to set meaningful tolerances.

This statement of reasons deals with particularity with the extent to which the registration should be continued for the following presently registered economic poisons: products containing DDT, 2,4,5-T, aldrin or dieldrin.

The economic poison DDT (Dichloro-diphenyl-trichloroethane) was the subject of a decision announced by the United States Court of Appeals for the District of Columbia Circuit on January 7, 1971 (Environmental Defense Fund, Inc. v. Ruckelshaus, ____ F.2d ____ (D.C. Cir., January 7, 1971)). This decision required this Agency to take two steps: (1) to commence the administrative process for cancelling the registrations of all products containing DDT; and (2) to consider whether the present

Preceding page blank 89-H

information available to this Agency warrants suspending the registration of these products immediately. Pursuant to this order of the court, notices of cancellation were issued January 15 of this year. (PR Notice 71-1).

The economic poison 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) was the subject of a separate decision of the same court also announced on January 7, 1971. (Wellford v. Ruckelshaus, _____ F.2d _____ (D.C. Cir. January 7, 1971).) Under this latter decision, this Agency is required to consider further the earlier decisions of the Government regarding registration of this economic poison for use on food crops, and to articulate the factors considered by this Agency in arriving at such decision.

*/ **/

The economic poisons dieldrin and aldrin have been the subjects of particular administrative investigation in the last year. This review has resulted in cancellation of the registrations for some uses of these products as well as an ongoing analysis at both the state and local level. In addition, a petition addressed to the Administrator of this Agency was filed on December 2, 1970, by the Environmental Defense Fund, Incorporated. This petition requested both suspension and cancellation of all products containing these two economic poisons.

In order to comply both with the orders of the court referred to above, and in order to articulate more fully the legal, scientific, and policy considerations on which our decisions are based, we have prepared the following statement.

I

THE STATUTORY MANDATE

Prior to the transfer of the responsibility to administer the FIFRA to this Agency, such duty was the responsibility of the Secretary of Agriculture.*** In the administration of the statute before 1964, the Secretary of Agriculture was compelled to register any economic poison upon the demand of any applicant for registration. In the case of a registered product which did not appear to comply with the provisions

*/ 1,2,3,4,10,10-hexachloro-6,7 epoxy-1,4,4a,5,6,7,8,8a-octahydro-exo-1,4-endo-5,8-dimethanonaphthalene.

**/ 1,2,3,4,10,10-hexachloro-6,7 epoxy-1,4,4a,5,8,8a-hexa-hydro-exo-1,4-endo-5,8-dimethanonaphthalene.

***/ The responsibility for the establishment of tolerances under the Food, Drug and Cosmetic Act was previously assigned to the Department of Health, Education and Welfare. Part of the rationale in establishing the Environmental Protection Agency was to consolidate these functions.

90-H

of the FIFRA, the Secretary was authorized to cancel the registration, but was required to issue a registration under protest, and to pursue any actual withdrawal of the chemical in a judicial forum.

In response to increased concern about the hazards of pesticides, the FIFRA was amended in 1964 by striking the requirement to register under protest and by providing instead mechanisms whereby the Secretary could initially refuse to register an economic poison, or could cancel or suspend an existing registration. The amendments provided administrative procedures by which an applicant or registrant could challenge the determination of the Secretary. The legislative purpose in enacting these amendments was to grant to the administrative officer charged with enforcement of the Act more effective procedures by which to protect the public by removing from the channels of interstate commerce any economic poison whose safety or effectiveness was open to substantial doubt (H.R. Rep. No. 1125, 88th Cong., 2d Sess. (1964)).

Statutory Tests

The statutory scheme pertaining to registration is complex. The thrust of the present FIFRA is to prohibit^{*/}

. those economic poisons which do not contain directions for use which are necessary and adequate for the protection of the public;

. those economic poisons which do not contain a warning or caution statement which is adequate to prevent injury to man, vertebrate animals, vegetation and useful invertebrate animals; and

. those insecticides or herbicides which, when used as directed or in accordance with commonly recognized practice, are injurious to man, vertebrate animals or vegetation (except weeds).^{**/}

In applying these statutory tests, the final decision with respect to whether a particular product should be registered initially or should continue to be registered depends on the intricate balance struck between the benefits and dangers to the public health and welfare resulting from its use. The concept of the safety of the product is an evolving one which is constantly being further refined in light of our increasing knowledge. These considerations formed the basis of the Administrator's first final cancellation order issued after completion of the administrative procedures set forth in the statute. In re Stearns Electric Paste Company, I.P.&R. Dkt. 13, entered January 4, 1971.

^{*/} Section 4c of the amended FIFRA authorizes the Administrator to refuse to register an economic poison if the data presented is insufficient to support the claims made for it, or if its proposed label does not comply with the various provisions of the Act.

^{**/} The Act provides that products which do not conform with these provisions are "misbranded" and may not be registered pursuant to the Statute.

91-4

Burden of Proof

A product which has previously been registered may either be cancelled or suspended if the Administrator determines that the product does not comply with these same provisions. It is clear from the statute, the legislative history, and judicial construction that the burden of establishing the safety and effectiveness of a product remains with the registrant from the time of initial application through continued registration of the product.*/

Cancellation

Recognition of the burden of proof is crucial to an understanding of the cancellation process. Judicial interpretations have emphasized that this initial step in the administrative process of deregistration is triggered whenever the Administrator determines from all the data before him that there is a substantial question as to the safety of a product. Issuance of a notice of cancellation is appropriate whenever it is decided that it appears that the registrant has failed to discharge his continuing burden of proof that the product meets the statutory standards including those pertaining to safety and efficiency.

Environmental Defense Fund, Inc. v. Ruckelshaus, supra, Slip op. at 14.**/
Recognizing the various considerations which must necessarily underlie final decisions as to a particular product, the Court also stated that the

"cancellation decision does not turn on a scientific assessment of hazard alone. The statute leaves room to balance the benefits of a pesticide against its risks."
Slip op., p. 15. See also S. Rep. No. 1379, 89th Cong., 2d Sess. 13, 27, 52, 64-65 (1966).

The cancellation decision is effective thirty days from the receipt of notice of cancellation by the registrant unless challenged by the registrant. Extensive administrative procedures are available to a registrant who chooses to challenge the notice of cancellation of

*/ See, e.g., S. Rep. No. 573, 88th Cong., 1st Sess. 5 (1963); H.R. Rep. No. 1125, 88th Cong., 2d Sess. 4 (1964); 11th Rep. of the Commission on Government Operations, H.R. Rep. No. 91-637, 91st Cong., 1st Sess. (1969); Environmental Defense Fund, Inc. v. Ruckelshaus, supra; Wellford v. Ruckelshaus, supra; In Re Stearns Electric Paste Company, supra; 7 C.F.R. 2764.1, et seq., formerly 364.1, et seq.

**/ Acting pursuant to this standard and as directed by the court, the Administrator has issued notices of cancellation for all registered domestic uses of DDT.

registration of his product (as well as for an applicant who challenges a refusal to register). He may exercise his statutory right to have a scientific advisory committee convened, or to have a public hearing held, or both.

Scientific Advisory Committee

When a statutory scientific advisory committee is convened, it is charged to receive and consider all scientific evidence concerning the registration of the economic poison in question. After consideration of all such data, the advisory committee presents its report and recommendations as to the scientific questions posed by the registration to the Administrator. The Administrator then makes a final policy judgment based on the scientific assessment and "all other data before him" as to whether to affirm the initial refusal to register or notice of cancellation or suspension. The registrant has the further option of requesting that the question be examined at a public hearing. At the conclusion of these administrative proceedings, judicial review is available to a registrant or applicant. (Section 4d.)* Pending the issuance of a final cancellation order at the conclusion of the administrative process, the economic poison may still be shipped in interstate commerce.

Suspension

The FIFRA also provides that the Administrator may suspend the registration of an economic poison immediately if he determines that such action is necessary to prevent an "imminent hazard to the public." This provision permits the Administrator to protect the public by prohibiting further interstate shipments of an economic poison so dangerous that its continued use should not be tolerated during the pendency of the administrative process.

The articulation of the criteria employed in applying the legal standard for suspension first adopted by the Seventh Circuit Court of Appeals**/is now well established. It was drawn from the legislative history of the 1962 amendments to the Food, Drug, and Cosmetic Act, which inserted a similar phrase in that statute,***/ since the

*/ However, section 4d provides that a final cancellation order may be stayed only by court order.

**/ Nor-Am Agricultural Products, Inc. v. Hardin, ___ F.2d ___ (July 15, 1970), vacated on other grounds en banc, ___ F.2d ___ (7th Cir. Nov. 9, 1970).

***/ On December 7, 1970, the Food and Drug Administration published in the Federal Register a definition of "imminent hazard to the public health" which invited public comment thereon. Both the FDA proposal and the comments have been reviewed by this Agency.

93-H

legislative history of the FIFRA amendments is silent on the point. These criteria received tacit judicial acquiescence in Wellford v. Ruckelshaus, supra, Slip op., at p. 5.

Based upon these legal guidelines, this Agency will find that an imminent hazard to the public exists when the evidence is sufficient to show that continued registration of an economic poison poses a significant threat of danger to health, or otherwise creates a hazardous situation to the public, that should be corrected immediately to prevent serious injury, and which cannot be permitted to continue during the pendency of administrative proceedings. An "imminent hazard" may be declared at any point in a chain of events which may ultimately result in harm to the public. It is not necessary that the final anticipated injury actually have occurred prior to a determination that an "imminent hazard" exists. In this connection, significant injury or potential injury to plants or animals alone could justify a finding of imminent hazard to the public from the use of an economic poison. The type, extent, probability and duration of potential or actual injury to man, plants and animals will be measured in light of the positive benefits accruing from, for example, use of the responsible economic poison in human or animal disease control or food production.

This Agency's responsibility for the setting of tolerances for economic poison residues in or on foodstuffs compliments the registration program. Safety from the perspective of the remote consumer is, of course, the primary and most pervasive criterion. Review must be continuous to reflect constantly changing knowledge upon which to base a determination of safe residues. As the Court of Appeals for the District of Columbia Circuit recognized, if there is no scientific basis for a reasonable estimate of safe dosage level "it would obviously be impossible to meet the congressionally imposed burden of establishing the safety of a residue of such a pesticide." Environmental Defense Fund, Inc. v. Dept. of Health, Education, and Welfare, 428 F.2d 1083, at 1092 (1970). Thus the tolerance mechanism functions to prevent unwanted residues from entering the human food chain and to reinforce the restrictions placed on a registered pesticide.

II

FORMULATION OF STANDARDS

The Court directed in Environmental Defense Fund, Inc. v. Ruckelshaus, that the "formulation of standards" applicable to the translation of the statutory standards to given factual situations be entrusted to the

94-H

Administrator, who "has an obligation to articulate the criteria that he develops in making each individual decision." Slip op., pp. 19, 20. The Court directed that consideration be given to the question of whether general standards could be promulgated ~~that~~ will determine whether cancellation or suspension was warranted in specific cases. However, the Court further recognized that such general standards might not be feasible. As an alternative, the Administrator was directed to articulate in each case the criteria applied. After intensive review of this issue, the Administrator has determined that it is not at this time feasible to articulate meaningful general standards which can be dispositive of all cases of cancellation or suspension. Rather, the Administrator has determined that the criteria applied to particular products be articulated on a case-by-case basis.

The problem of universally applicable criteria is also acute when facing the question of determining tolerances for pesticide residues on foodstuffs. In Environmental Defense Fund, Inc. v. Department of Health, Education, and Welfare, 428 F.2d 1083 (D.C. Cir. 1970), the Court articulated the concerns which bear upon the determination of tolerances for DDT on foodstuffs and ordered that the Administrator consider the feasibility of adopting zero tolerances for that economic poison. The Food and Drug Administration, the predecessor of this Agency in administering the Act, proposed reduced tolerances for DDT on December 5, 1970 (35 F.R. 18,531), prior to the issuances of notices of cancellation as to all registrations of DDT.*

After balancing the desirability of giving general guidance and the magnitude of the variables intrinsic in particular decisions, the Administrator has determined that the standards and criteria necessary for setting pesticide tolerances on foodstuffs must also be developed on a case-by-case basis.

Despite the impossibility of articulating meaningful criteria that can provide a formula for the decision of the particular case, as discussed above, certain general factual and policy variables can be stated. For example, any discussion of the term "safety" in the context of chemical economic poisons must recognize that each of these substances is by design toxic to some form of life. It is designed to kill or otherwise adversely affect a particular pest. Modern technology has not yet developed to the point where such toxic

* On January 4, 1971, the Environmental Defense Fund and the other parties to that litigation filed comments opposing this proposal.

95-H

substances can be designed with scalpel-like precision -- that is, toxic only to one discrete pest. Thus, economic poisons are to some degree ecologically crude because they have some undesired effect on various non-target species or strains of vegetation.

These unwanted side effects -- danger to non-target species -- are acceptable only to the extent that the benefits accruing from use of a particular economic poison outweigh these adverse results. For example, certain classes of economic poisons are particularly effective against disease-bearing insects. This class of economic poisons has permitted the dramatic steps in disease control which have been realized on a worldwide scale in the last two decades. Certain economic poisons have been vital to the general well-being of mankind by permitting vast increases in the amount and quality of produce available. The dramatic increases in yields per acre in the agricultural sector achieved in the last generation are to some degree due to use of various economic poisons. The chronic problem of world hunger has thus, to some extent, been ameliorated by use of these chemical substances. In addition, the persistent economic poisons -- those whose chemical characteristics permit their continued toxicity to pests over a relatively long period of time -- have the added economic benefit of reducing the number of applications of the chemical needed, and thereby lowering labor costs, and additionally lowering initial application rates.

Nonetheless, this Agency will not permit the triumphs of public health achieved in the past to be a continuing justification for use of a particular substance in the future. To this extent, the requirements for use of economic poisons in a relatively developed country such as the United States may force a divergence from what is permitted in the developing countries where the public health impetus for control of such diseases as malaria may require continuing use of pesticides whose side effects would no longer be tolerable here.*/ This Agency is fully aware of its statutory directive and duty to the public to place the dictates of health and safety over economic considerations in its scale of values. But health narrowly defined must be distinguished from the broader concern of environmental quality -- the synthesis of all of the variables in the ecosystem.**/

*/ As the Surgeon General pointed out in a letter to this Agency dated February 3, 1971, DDT is presently being used in foreign countries to protect some 350,000,000 people from the scourge of malaria. Ninety percent of this DDT is produced in the United States, and is distributed through AID and UNICEF. This cardinal role in world health is unaffected by our decisions as to domestic use. We do not presume to regulate the felt necessities of other countries.

**/ See Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, p. 261. (Hereinafter cited as Mrak Commission Report.)

96-H

Present use of the economic poisons in the United States is, of course, widespread. These substances are applied to approximately five percent of the total land area of the continental United States. At the present time, hundreds of chemical substances are used against over 2,000 particular insect and plant pests. There are presently nearly 45,000 individual registrations.

The particular products registered vary tremendously as to initial toxicity, persistence in the environment, and effect on non-target species. One of the reasons why the governmental decisions as to registrations and tolerances are most critical is that once certain economic poisons are introduced into the environment remote from the consumer, the individual has no choice as to whether or not to accept substances contaminated thereby. For example, in the Mark Commission Report, the observation is made that "the hazards to health that stem from environmental exposure to chemical agents are usually beyond the capacity of the individual to control." This is particularly true for the persistent pesticides, such as DDT, the residues of which are now found in many foodstuffs and especially animal products available in the United States and in the adipose tissue of humans and other biota. Certain classes of health threats deserve particular searching. Positive results on laboratory animals from tests for carcinogenicity, teratogenicity and mutagenicity are particularly disturbing because effects are generally irreversible when discovered.

Yet it is not merely the chemical characteristics of a given economic poison which control its dispersion in the environment, since the means of application of the particular economic poison are also of cardinal importance. Introduction of a particular product by air or directly into the water will usually cause a much wider and faster dispersal than that of the same substance inserted into the ground.

In general the presently used insecticides vary in toxicity as one moves up the biological chain to more complicated animal life. Due to the persistence of certain substances and their accumulation in the food chain, some higher life forms may receive dosages of a particular substance manyfold more concentrated than is found in the ambient environment. Certain predatory animals are particularly vulnerable to a buildup of a particular substance.

As with any generalizations of this magnitude, the foregoing analysis is not dispositive in the particular since the number of variables underlying each assumption is so vast. For example, both dispersal of a particular pesticide and its effect on the life chain of other vertebrate non-target

97-H

species vary with climatic and geographic factors, and a host of other considerations not susceptible to generalization. The concentration in a single food source for an omnivorous species does not determine the total intake of that pesticide for individuals of that species. In addition, generalizations drawn from the accumulation in food chains of the persistent economic poisons must take into account both world-wide uses which contribute to the maintenance of a low level background accumulation, and changing domestic use patterns. Use in this country of herbicide economic poisons exceeded that for insecticides for the first time in 1967.

Although the drafting of detailed criteria has been found to be a practical impossibility, the following general considerations are among those which will be weighed in determining the need for initial or continued registrations of particular economic poisons:

(1) The nature and magnitude of the foreseeable hazards associated with use of a particular product. Such hazards may apply directly to human health, or to domestic plants and animals, or to wildlife, or to the environment generally. It is relevant to consider also whether the hazard is inherent in the normal use of the product or whether it results solely from misuse. The fact that danger results solely from misuse does not determine that such danger is to be ignored but that this consideration has a possible bearing on the magnitude and possibility of occurrence of the risk.

The consideration of human health hazards underlines dramatically the impossibility of setting up value weighted general criteria. It is possible to determine with some degree of scientific precision the acute oral, dermal and respiratory toxicities of particular economic poisons. However, quantification of the damage from possible subtle health effects resulting from long term low level effects, in particular, carcinogenicity, mutagenicity, and teratogenicity (proclivity of the chemical to cause cancer, mutations or birth defects, respectively) are often beyond the present scientific state of the art. In projecting the magnitude of risk from these sources, two extremes must thus be avoided: insistence on final hard scientific evidence of occurrence of the injury in humans, which may only occur when the process leading to this result is irreversible; and action based only on anxiety, which may deprive mankind of a badly needed control mechanism.

Attention has also been directed to long term genetic, behavioral or synergistic effects of certain economic poisons alone or in concert. However, scientific analysis of these possibilities is still in a primitive state and the extensive testing necessary has not been undertaken.

98 - H

Rectification of this omission in the available data is a matter of utmost concern to this Agency. Development of adequate testing protocols and facilities is a priority undertaking. But in the short term, extrapolation from small scale laboratory analysis must err on the side of safety.

Because it is easier to test plants and animals in a laboratory setting than in the biosystem, most of the available data are generalizations and projections based on such experimentation. The question of the gross effects of introduction of these artificial controls into the environment is still largely a matter of controversy. Furthermore, there is much debate over how to relate laboratory results on small numbers of test animals at high dosage levels to low-level long term human exposure.

(2) Concurrently, the nature of the benefit conferred by use of a given product must be weighed. Pesticides are used for a variety of purposes in a multitude of situations. Some uses are obviously more important to the public health and well being than others. It is necessary in each instance to detail with particularity the nature of the benefit. Some pesticides play a major role in the control of important disease vectors. Others play important roles in the production and protection of adequate supplies of essential food products. These two uses are probably the most important benefits man has gained from pesticide use. There are also important uses in the production and protection of forest resources and fiber crops. Other uses are directed toward what may be called nuisances, such as insects or weeds that annoy or inconvenience man.

Not only the nature of the benefit must be weighed. The other side of the coin is to assess the magnitude of the social cost of foregoing the use of a given economic poison. Thus, an estimation must be made of the effect of absence of the economic poison: whether it would merely cause some inconvenience to would-be users, or would cause serious risk to public health, or disruption of important social needs.

A further consideration in this regard is the alternative, if any, to use of a given economic poison and any problems associated with such substitution. Such alternatives may be other toxic chemicals, which may themselves cause greater or lesser problems, biological control of insects, or physical removal of plants in place of herbicide usage. Another factor is the desirability and feasibility of increased use of manual labor as an alternative to technological control.

99-H

In summary, each question of initial registration, or cancellation or suspension of an existing registration must be individually addressed. The range of variables in the chemical formulation, pattern of use, risk and benefit is too broad to permit responsible general criteria. This Agency will discharge its duty to coordinate the various indicia of environmental quality -- both positive and negative -- that flow from a particular registration decision mindful of the requirement to set forth the rationale upon which its action is based. From such decisions, forged in the administrative forum provided by statute, should evolve the standards for rational use of the products which will permit maximizing overall environmental quality.

III

DDT

After applying the foregoing analysis and the criteria of risk and benefit to the products containing DDT, this Agency has determined that suspension of such products is warranted pending completion of the administrative process of cancellation which has been commenced. For the reasons stated herein, the hazard to the public is not found to be imminent so as to require suspension during the pendency of the administrative determinations.

In January, 1971, this Agency issued notices of cancellation with respect to all registrants of products containing DDT. Many of these registrants have filed objections and requested a public hearing as provided in the FIFRA. Answers and motions are presently being prepared by the Agency and every effort will be made to ensure that these cases are brought to public hearing as soon as possible. Section 4c sets forth a complex procedure culminating in a final order by the Administrator. We anticipate that, in the absence of unforeseen delays, these administrative procedures may be concluded within one year. Unless the registrants can discharge their burden of proof regarding the safety and efficacy of such products, all registrations will be cancelled at the conclusion of the administrative process.

Such a procedure, despite the time required, offers the opportunity for a full presentation of the conflicting views of all concerned parties with relevant data to be made part of the record, and for an orderly consideration of all the evidence which has been amassed concerning DDT. Because suspension may be ordered at any time, our present decision does not foreclose the possibility of such an action in the event that evidence adduced during the administrative process meets the test for suspension.

100-H

The question presented now is whether the continued use of products containing DDT constitutes an "imminent hazard to the public," which requires immediate suspension prior to conclusion of the administrative proceedings. After review of all relevant data bearing on the nature of DDT and its effect on man and the biota, this Agency has determined that the uses which will be permitted to continue do not present such an imminent hazard to the public.*

Environmental Data

This determination is supported by the nature of the present effects of DDT. DDT is a hazard by virtue of its potential toxicity at prolonged low levels of exposure. This hazard is made acute by the persistence, mobility, and biomagnification of DDT in the environment. Recognizing these characteristics, the four governmental committees which have studied the DDT problem in depth between 1963 and 1969 have all recommended that its use be phased out over a period of time.** None have recommended an immediate ban. However, the time has come for resolution of the DDT issue in light of the standards set out in the FIFRA. This is now being done through the orderly administrative forum provided by the statute in the cancellation proceedings.

DDT has been a topic of special concern as an environmental contaminant because it has been the most widely used pesticide and is thus presently the most ubiquitous in the environment. Like other broad spectrum pesticides, it is ecologically crude in that it is not wholly specific to insect pests, but has a variety of effects on many non-target organisms as well. Although its initial use was mainly for disease vector control during and immediately after World War II, it is presently used in the United States for a variety of uses including the control of a variety of insect pests on various agricultural crops. Domestic use of DDT has declined notably in recent years. From a peak of 79 million pounds in 1959, domestic use dropped to approximately 10 million pounds in 1970. Correspondingly, there has been a drastic

*/ In contemplation of this decision, this Agency published in the Federal Register a request for comment as to the imminence of the hazard. With respect to DDT, over 500 responses have been received from individuals, civic organizations, manufacturers, universities, and state and local government agencies. Review and analysis of these responses has proved useful in arriving at our present decision.

**/ "Use of Pesticides," A Report of the President's Science Advisory Committee (May, 1963); "Restoring the Quality of our Environment," Report of the Environmental Pollution Panel, President's Science Advisory Committee (November, 1965); Report of the Committee on Persistent Pesticides, Division of Biology and Agriculture, National Research Council, to U.S. Department of Agriculture (May, 1969); Mark Commission Report (December, 1969).

101-H

reduction in the number of registered uses for DDT as a result of cancellation actions which have already taken effect.*

The two most common allegations concerning the hazards resulting from use of DDT are that it has detrimental effects on many non-target organisms, especially birds, fish, and crustaceans, and that it is possibly a carcinogen to man.

A substantial question has been raised that DDT and its metabolites (such as DDE) are "highly injurious to some non-target species and threaten other species and biological systems."**/ DDT has apparently contributed to reproductive failure in many raptorial birds, such as the bald eagle, the peregrine falcon and in the brown pelican. In addition, it has either potential or actual deleterious effects upon many species of fish fry and other aquatic organisms.

It is more difficult to draw hard conclusions as to the allegations concerning human health effects of DDT use. There is scientific support for the proposition that DDT poses no significant hazard to human health.***/ The most widely accepted scientific assessment of the carcinogenic threat from DDT is the one which concluded the report on that subject by the Mrak Commission:

"Accordingly, with the evidence now in, DDT can be regarded neither as a proven danger as a carcinogen for man nor as an assuredly safe pesticide; suspicion has been aroused and it should be confirmed or dispelled." Mrak Commission Report, p. 471.

*/ See, e.g., PR Notice 69-17, November 20, 1969, which cancelled all DDT products for use on tobacco and shade trees, for use in or around the home, and all uses in aquatic environments, except those essential for the control of disease vectors as determined by Public Health officials; PR Notice 70-19, August 18, 1970, which cancelled the registration of DDT products for certain uses on a wide variety of crops, animals, and products.

**/ Mrak Commission Report at p. 9; see also p. 180.

***/ A notable example is Dr. Wayland Hayes, Jr., formerly of the U.S. Public Health Service and now of the Vanderbilt University School of Medicine. See, e.g., Hayes, "Toxicity of Pesticides to Man: Risks from Present Levels," 167 Royal Soc. (London) Proc. Ser. B. 101 (1967). In addition, the Committee on Occupational Toxicology of the American Medical Association has recently characterized the statement that "DDT is carcinogenic to man" as a "speculation as yet unproved" and calls it merely a "general accusation and anxiety-provoking statement." J.A.M.A. 212(6): 1056 (May 11, 1970). However, for the legal and policy reasons discussed above, this Agency will not permit its administrative action to await positive scientific assurance in the face of pervasive risks to health and welfare.

102-H

The "suspicion" referred to is the result of tests with animals which indicate DDT in high dosages is a carcinogen as to particular species. See Innes, et al., "Bioassay of Pesticides and Industrial Chemicals for Tumorigenicity in Mice: A Preliminary Note." 42 J. Nat. Cancer Inst. 1101 (June, 1969). Some studies have also shown DDT to be more highly concentrated in the tissue of cancer victims than in the general populace. However, the relevance of such studies to human health continues to be in debate. One of the scientists responsible for the latter study has expressly disavowed, in a letter to this Agency, the relevance of such findings to causation of cancer in human beings.*

In addition, there are unpublished studies conducted under the auspices of the Food and Drug Administration showing a percentage increase, in comparison to a control group, in fetal mortality in rats administered large doses of DDT.**/ Allegations have also been made that some data suggests that relatively low level exposure may cause subtle behavioral changes and that DDT and its metabolites in laboratory tests have been observed to cause alterations in steroid balance.***

DDT continues to find strong support in some segments of the scientific community. Its low direct toxicity to man and other higher forms of animal life has made it easily accessible to the mass of users without short-range hazard. Despite the large number of other chemical pesticides developed and introduced since 1945 and the strides made in research and introduction of biological control of certain discrete pests, DDT remains the only practical pesticide which is effective against certain species of insect pests.****/

*/ Letter of December 22, 1970 to Dr. Raymond Johnson, Environmental Protection Agency, from William B. Deichmann, Ph.D.

**/ Legator, "Mutagenic Effects of DDT and other Pesticides in Rodents and Cultures of Mamalian Cells" (Seminar: Brookhaven National Laboratory, 1970).

***/ Affidavit of Charles F. Wurster, Ph.D., at p. 3; Comments to Department of Health, Education and Welfare by Environmental Defense Fund, et al., dated January 4, 1971.

****/ Though numerous jurisdictions in the United States and abroad have experimented with radical restriction of the use of DDT, most have found it necessary to provide for exceptions to control particular pests. Thus, for example, Michigan permits use of DDT for the control of mice and bats, Sweden permits its use for the control of the large pine weevil and the Province of Ontario in Canada permits its use for control of the cutworm on onions.

103-H

Other Factors

Precipitous removal of DDT from interstate commerce would force widespread resort to highly toxic alternatives in pest control on certain crops. The widespread poisonings, both fatal and non-fatal, which may reasonably be projected present an intolerable short-term health hazard. During this period of withdrawal from the broad spectrum applications of DDT, and in anticipation of the probability that DDT will shortly become unavailable for the majority of its present mass uses by virtue of state and federal restrictions, this Agency will strongly support the continuing efforts to educate pesticide users to the dangers inherent in certain substitute economic poisons in order to reduce this danger.

Finally, the very characteristics of DDT which raise fears of its effect as an environmental contaminant -- its persistence, broad distribution and usage -- have made it the most economically attractive pesticide for a variety of uses. Its persistence permits relatively long intervals between applications, while broad usage has dramatically lowered the cost per pound. However, as in other areas of environmental pollution, if a product contributes to contamination or degradation of the ecosystem, an assessment of its true economic cost must take these adverse effects into account. Thus while economic considerations have a place in the policy-balancing functions which this Agency is charged to perform, the economic factor is much more complex than a simple estimate of unit production cost. In addition, any rational balance must recognize the clear predominance of environmental concerns over purely economic considerations. Thus the economic data regarding DDT is not the gravamen of our decision.

Complementary Actions

Our review of this question is strictured by the present statutory framework. The most logical course of action would be to restrict uses to situations of real need, thus reducing the possibility of inadvertent overuse. In addition, it would be preferable to have definite control of particular uses, rather than the present authority to act merely through labeling.

The present scientific evidence indicates that there would be no significant hazard if only carefully limited amounts of DDT were released into the environment by virtue of restriction of DDT to the most critical uses. Achievement of this goal would require that fields be checked to assure that the infestation justified treatment and that the dosage and application methods were not wasteful. Without such assurance, experience has shown that the use of DDT would become routine and that the ease of availability of DDT would permit much of it to be used for nonregistered purposes.

104-H

Federal authority is presently focused on controlling the entry of hazardous or ineffective products into the marketplace. A more limited control of the use of a pesticide is achieved by specific instructions on the label and the enforcement of residue limits on and in food products. Actual control of use by these methods is far from adequate. In order to remedy these imprecise administrative tools, the President recently recommended to the Congress a legislative revision which would allow this Agency to make more focused individual determinations. Under this legislation, economic poisons are assigned to various categories. The most potentially hazardous product could not be purchased without a certification by a pest control consultant that the application of that pesticide to a particular location at that particular time is appropriate. This more selective control of ultimate use will permit our society to reap the benefits of scientific advances without paying an intolerable environmental price.

Another aid to rational utilization of DDT is through enlightened control by the states. In the light of present information concerning the health hazards associated with mass uses of DDT, we hereby encourage each state to scrutinize its own needs for the substance and to reduce its use as drastically as is consistent with the health and well being of its citizens. It is recognized, however, that at present techniques of state control of use patterns are neither well enough tested nor widely enough available to assure the protection of the environment from DDT. Since, as discussed above, the hazard to the public is not imminent, and present federal law offers no mechanism whereby the Environmental Protection Agency can effectively register pesticides for particularized restricted uses and assure compliance, we have been compelled to cancel all uses of DDT, to initiate the administrative process, and to stimulate the resourcefulness of the states, the manufacturers, and the scientific community to find acceptable substitutes.

IV

DIELDRIN-ALDRIN

In early 1970, based on a concern to restrict aldrin and dieldrin, two chemically similar chlorinated hydrocarbon pesticides, from wide dispersal in the environment, the United States Department of Agriculture cancelled all registrations for these products in or on aquatic areas.*

*/ PR Notice 70-6.

105-H

In May of last year, USDA published in the Federal Register a request for public comment on the question of what revisionary uses should be continued. A list of possible substitutes for aldrin and dieldrin were circulated to both state and federal agencies for comment. A special review group was established within the Department to evaluate these data. Their report was forwarded to this Agency in January of this year.

In December of 1970 the Environmental Defense Fund, Inc. filed a petition with the Administrator of this Agency requesting immediate cancellation and suspension of all registrations of dieldrin and aldrin. The petitioner contends that each substance causes severe environmental damage and that each is a potential carcinogen.

The material relating to the general impact of these substances on the environment contained both in this petition and in the entire body of scientific literature which has been developed regarding these substances, raises a substantial question as to the safety of the registered products which has not been effectively countered by the registrant. This Agency has thus determined to commence the administrative process in order to resolve these questions by issuing notices of cancellation as to all registrations of the products containing aldrin and dieldrin.* Because, for the reasons set out below, this Agency has determined that the present uses do not pose an imminent threat to the public such as to require immediate action pending the outcome of the administrative process, the statutory remedy of suspension will not be ordered.

Use of dieldrin and aldrin has declined greatly in recent years. In 1956, dieldrin usage in the United States reached a peak of 3,635,000 pounds applied. By 1970, usage had declined to 714,000 pounds. Aldrin usage peaked at 19,000,000 pounds in 1966 and declined 4,500,000 pounds in 1970. Dieldrin is used primarily for termite control, as a seed treatment, on nursery stock, ornamentals and turf. Aldrin is used primarily as a soil treatment for corn and citrus, for termite control, as a seed treatment, and on nursery stock, ornamentals and turf. The largest volume of use is as an insecticide for corn (aldrin); the second largest volume is applied for termite control (both aldrin and dieldrin).

*/ The registration of a house paint containing dieldrin was cancelled on April 28, 1970. This action was challenged administratively by the registrant and a public hearing was held on November 17, 1970. A final decision with respect to this registration will be announced shortly.

106-H

Environmental Data

The questions raised concerning the safety of these products are similar to those encountered with DDT in that they result from the persistence of dieldrin (since aldrin residues quickly break down into dieldrin) in the environment and its potential toxicity at low levels. Some studies indicate that dieldrin alone, or in possibly synergistic combination with DDT, has an equivalent potential for adverse effect on non-target predatory wildlife resulting from its low level toxicity intensified by its mobility and concentration up certain food chains. The scientific data also indicate that dieldrin, again like DDT, has an affinity for storage in the fatty tissue of a number of animals, including humans.*/ There are also similar carcinogenic data developed in the laboratory from high dosage rates of dieldrin administered to test animals.

Dieldrin and aldrin apparently have a lower threshold of toxicity to warm-blooded animals than does DDT. In fact, instances of non-lethal human poisoning have occurred in those occupationally exposed to heavy concentrations of dieldrin for protracted periods. Recovery following removal from exposure was slow but apparently complete.**/ These potential hazards deserve a full public airing in the administrative forum provided by the cancellation proceeding.***/

But because the vast majority of the present use of these products is restricted to ground insertion, which presents little foreseeable damage from general environmental mobility, because of the pattern of declining gross use, and because the lower historic introduction of these products into the environment has left a significantly lower environmental residue burden to be faced by man and the other biota, the delay inherent in the administrative process does not present an imminent hazard. Thus the substantial question of the safety of these registrations is primarily raised by theoretical data, while review of the evidence from the ambient environment indicates that such potential hazards are not imminent in light of the present registrations.

It is significant to note that no residues of either aldrin or dieldrin are now permitted on corn, eggs, milk, poultry, or animal fats shipped in interstate commerce. Because of the use patterns of aldrin and dieldrin, these products constitute the major sources whereby these substances would find their way into human food chains. During the pendency of the administrative process hereby initiated, this Agency

*/ Mrak Commission Report, pp. 265, et seq.

**/ Wayland J. Hayes, Jr., "Dieldrin Poisoning in Man," Public Health Report No. 72, pp. 1087-1091, Dec., 1957.

***/ See Environmental Defense Fund, Inc. v. Ruckelshaus, supra.

will take no action to grant any residue tolerances for these foodstuffs pursuant to the Food, Drug and Cosmetic Act, although initial tolerances have been requested by the manufacturer.

V

2,4,5-T

Notices of cancellation and suspension for products registered for certain uses of 2,4,5-T were issued in May of 1970.*/ This action has been challenged by four manufacturers of the products who have requested review pursuant to the statute by a scientific advisory committee. This advisory committee first met on February 1, 1971, and its evaluation of the scientific evidence relating to products containing 2,4,5-T is expected shortly. While these procedures were being prosecuted, certain petitioners commenced a court action which sought to broaden the suspension notices to include all registered products containing 2,4,5-T for any use. Although approving the standard for suspension applied under the FIFRA in the case of 2,4,5-T, the court remanded the case to this Agency for further consideration of that legal standard as applied to the relevant facts in this case. After careful consideration of the petitioners' allegations and of all other relevant factors, the Administrator has determined that, for the reasons detailed below, the uses of 2,4,5-T which have not been suspended pose no imminent threat to the public, and should be permitted to continue during the pendency of the administrative proceedings now in progress.

The compound 2,4,5-T**/ is a herbicide used for a wide variety of brush and weed control in the United States, primarily for nonagricultural purposes.

*/ Suspension was noticed for use of products containing 2,4,5-T in lakes, ponds, and ditch banks, and in liquid formulations around the home, in recreational areas, and similar sites. Cancellation was noticed for the use of such products on food crops intended for human consumption and for all granular formulations around the home, in recreational areas and similar sites. In addition, the next month the Secretary of the Interior banned all use of 2,4,5-T on lands under the control of the Department of the Interior and the Department of Defense ordered the immediate cessation of the use of 2,4,5-T in the defoliation program in Vietnam.

**/ 2,4,5-T is not a chlorinated hydrocarbon like DDT, aldrin and dieldrin. It is a phenoxy herbicide.

108-H

Environmental Data

Acting under contract to the National Cancer Institute, Bionetics Research Laboratories, Inc. undertook a large-scale screening study of 86 chemical compounds. In 1969, the results of the Bionetics studies showed 2,4,5-T to be "causing significantly more deformities than expected" to strains of mice and rats. Cleft palate and cystic kidney were the teratogenic effects shown. Subsequent studies were undertaken by both governmental and private organizations when it became known that the Bionetics 2,4,5-T samples contained 27 ± 8 parts per million (ppm) of the highly toxic contaminant 2,3,7,8-tetrachlorodibenzoparadioxin (TCDD). Tests by other researchers indicated no teratogenic effects at dosage levels of 24 mg./kg. per day with TCDD levels below 1 ppm. However, the National Institutes of Environmental Health Sciences conducted tests which showed 2,4,5-T to be teratogenic to rats, though not mice, at levels of 100 mg./kg. (though not at lower levels, suggesting the existence of a "no effect" level for 2,4,5-T), with the purest commercial samples of 2,4,5-T available. Subsequent tests announced in a report issued in December, 1970 by Bionetics show no teratogenic effect from commercially pure 2,4,5-T, apparently at the lower dosage level of 10 mg./kg. ✓

Since 2,4,5-T is not directly toxic to man or other species of animals, and is not persistent in the environment, there are but two health issues to be considered in the controversy over 2,4,5-T: (1) whether 2,4,5-T alone or in concert with its dioxin, TCDD, is actually a teratogen, and (2) if so, what action is necessary to eliminate the hazard to human health (particularly to field workers and consumers).

The question of the teratogenicity of 2,4,5-T and TCDD is presently before the scientific advisory committee appointed pursuant to the FIFRA. Its report is due on or before May 14, 1971. Prior to this complete explication of the present scientific judgment relating to these matters, this Agency has undertaken its own review of the presently available data. A notice soliciting the views of interested parties was published in the Federal Register on January 20, 1971 (36 F.R. 948). This Agency has received voluminous comments in response which have been particularly helpful to our present analysis.

From these data the Administrator has concluded that the teratogenic threat from 2,4,5-T and its dioxin remains in sharp scientific debate. The substantial question to health raised by the cancelled registrations is being administratively prosecuted. To the extent

*/ The manufacturers of products containing 2,4,5-T were instructed by the USDA to eliminate chlorodioxins such as TCDD from such products on September 28, 1970. (PR Notice 70-22.)

that any positive evidence of teratogenicity in test animals exists, it is clearly dose-related. To the extent that the restrictions presently applicable to human exposure to products containing 2,4,5-T are based on incomplete scientific data, they err on the side of safety. The data shows that even direct accidental spraying of workers in the field would yield oral equivalent dosages hundreds of times below the levels at which the laboratory tests produced the teratogenic results. The suspension of liquid formulants for use in the home was based on restricting the possibility of direct oral ingestion of high concentrations of 2,4,5-T by pregnant women while exploration of its possible teratogenic effect was under study. The epidemiological data from the experience of extremely heavy dosages of 2,4,5-T in Vietnam on humans as a by-product of the defoliation program has shown no cause for further domestic restrictions.

Thus the restrictions now in effect, which obviate direct water contamination and virtually eliminate the threat of dangerous direct exposure to the one group who might receive adverse effects if the substance were shown to be teratogenic -- pregnant women -- provide so vast a margin of safety as to permit the benefits from use of 2,4,5-T for the control of unwanted vegetation to be continued pending resolution of the administrative proceedings.

VI

FUTURE ACTIONS BY THIS AGENCY IN REGARD TO PESTICIDES

Because of our statutory mandate to protect the public health and well-being by the rational control of economic poisons, this Agency is undertaking a comprehensive review of its administrative mechanisms in order to ensure intensive and regular review of all economic poisons that may be identified as possibly significant environmental contaminants. Active internal review is being initiated as to the registrations of products containing benzene hexachloride, lindane, chlordane, endrin, heptachlor and toxaphene, all products containing mercury, arsenic or lead, and all others deemed necessary for review.* The function of this review is not to make another study of pesticides (which function the Report of the Mrak Commission already admirably serves), but to identify which, if any, of the presently registered products present substantial questions of safety that should trigger the administrative process of cancellation.

* Mrak Commission Report, Recommendation 4, at pp. 9-10.

In this undertaking, this Agency welcomes additional submissions with regard to particular products from other governmental sources, manufacturers, the scientific community, or concerned citizens to assist in the task of accommodating the needs of mankind to the demands of the environment. But, if we are to do more than merely stultify the needed search for agricultural improvement in the face of the intensifying world hunger problem, and protection from insect-borne disease vectors, we must do more than subject our present chemical products to a continuing review. These same sources of information whose views we hereby solicit must be encouraged to push the search, not only for safer chemical control agents, but for bioenvironment controls^{*/} and improved growing practices.

^{*/} "Restoring the Quality of Our Environment," President's Science Advisory Committee, p. 230 et seq. (1965).

111-H

The contractor does, however, wonder why the Administrator had no objection to the continued export of DDT if, as the abundant testimony received before the hearings held during the first session of the 97th Congress (Committee on Agriculture, House of Representatives and Subcommittee on Agricultural Research and General Legislation of the Committee on Agricultural and Forestry, United States Senate, and others) show that DDT and the cyclodienes have created a global problem as well as a national problem. The scientific testimony would seem to indicate that global influence of these chemicals may be of far greater magnitude than any local considerations.

Identity of Favorable Types of Laws

As stated above, the contractor supports the Administration bill (H. R. 10729); although some states presently have laws which appear to control use and application, it is seen that sufficient control is not observed in practice at all times. The provisions of H. R. 10729 will undoubtedly result in increased financial responsibility in written state laws. Hopefully the provisions of the bill which would strengthen or reinforce federal aid to educational programs designed to improve methods of application and human safety would have their impact in increased environmental protection as well.

The inclusion of specific restrictions into updated state laws is seen as a function of state government. All states, it would appear, should be able to make laws more restrictive than the federal law.

Some of the verbiage of the existing state laws is rather loose in the interpretation of how to dispose of containers and unused pesticide. Hopefully this major source of environmental contamination will be solved by more useful state laws in the future. As indicated in another section of this report, many farmers have expressed an earnest desire to dispose of their material in a suitable way but do not know of a practical solution. Aid in this matter should come from all states as soon as possible.

Assistance to farmers by way of increasing their ability to implement soil erosional control techniques would have the multiple advantage of increasing crop yield, keeping soil loss to a minimum and, most importantly, keeping pesticides used on the land where they are normally effective. An obvious benefit would occur to farmers since annual application of certain compounds could be adjusted downward to take advantage of residue.

The strengthening of applicator laws is viewed as another very desirable feature of some laws. Responsible operators who perform valuable services should not suffer from over-regulation. Irresponsible, thoughtless operators will hopefully make their operations more efficient or

suffer sufficient financial loss to make the venture unprofitable.

In any event, the restructuring of state laws along the lines of the AAPCO in conjunction with the new Administration bill should go a long way in providing better safety for all citizens as well as the environment as a whole.

One additional case which should be commented upon is that of Burk vs. Stauffer Chemical Co. in the Kansas City United States District Court in November, 1970. This case did not receive wide publicity. Judge William H. Becker concluded on November 24, 1970, that "Donald C. Burk died as a direct and proximate result of exposure to Dieldrin 1.5-E formulated by the defendant Stauffer Chemical Co." The judge indicated medical evidence showed that the exposure caused overreaction of Burk's lymph system with the resulting development of Hodgkin's disease, characterized by enlargement of lymph glands, spleen and liver. Without delving into any more of the case, it appears this decision was made primarily to allow the deceased's widow and children eligibility under workmen's compensation laws - compensation which had previously been denied. The contractor feels decisions of this kind, although obviously filling a need to overcome some shortcomings in existing rules and regulations (i.e., compensation for loss, injury or death

in proper performance of the job), do make bad laws if used for precedent. The contractor was unable to find a medical doctor who would testify that the medical evidence was sufficiently strong to suggest an intimate relationship between dieldrin exposure and Hodgkin's disease.

Important Litigation

Court cases in the five states concerning pesticides were reviewed to determine important points of law involved in the decisions. Only those cases tried in a court of record, i.e., State or Federal Court of Appeals, District Court or Supreme Court, could be reviewed. Law digests and indices of Court Reporters were used to research all litigation involving pesticides from 1956 to mid-1971.

Cases adjudicated in appellate courts of the five states during that period are summarized in Table 3-H. However, those cases undoubtedly represent a negligible percentage of actual litigation; most suits are initiated for recovery of damages in amounts which only warrant trial in magistrate or district courts. For example, review of an Iowa newspaper by the contractor revealed that a local district court jury awarded \$70,595 in damages to a rural couple who claimed that the woman suffered physical and mental impairment from an insect killer which was not properly marked to indicate possible danger (1). There is, however, no systematic means of retrieving records of such

TABLE 3-H
LITIGATION INVOLVING PESTICIDES IN ILLINOIS, IOWA, KANSAS, MINNESOTA, AND MISSOURI, 1956-1971

Court	Year	Case	Summary
Court of Appeals, Minnesota	1963	<u>Land O'Lakes Creameries v. Hungerholt</u>	Contamination of dairy products resulting from use of defendant manufacturer's insecticide on dairy farm. Decision was that label disclaiming liability does not relieve manufacturer or compounder of his duty to suitably convey notice of danger of product containing deadly ingredients, so that proper precautions may be taken to prevent wrongful use and consequent injury.
Kansas Supreme Court	1964	<u>Stertz v. Briscoe</u>	Death of child after using bathtub in rented premises following fumigation with an insecticide containing parathion. Evidence established that spraying of bathtub with parathion was direct and proximate cause of death of child.
District Court, Missouri	1965	<u>Hunter v. E. I. duPont and De Nemours and Co.</u>	Personal injury sustained as a result of exposure to the spray while applying a weed killer to the lawn at his residence. Verdict declared that caution statement on label of manufacturer's product that contact with eyes, skin, and clothing should be avoided, and that solution might cause skin irritation was an adequate warning of any hazard to life or health which might result from use of product, and that manufacturer was therefore not negligent in failure to place an additional warning on its label.

TABLE
Continued

Court	Year	Case	Summary
District Court, Iowa	1966	<u>Holladay v. Chicago, B. and O. Railroad Co.</u>	The railroad's negligence with respect to herbicides sprayed on right-of-way was judged a proximate cause of plaintiff switchman's condition of acute and disabling neuritis that existed after date of exposure.
<u>Missouri Court of Appeals</u>	1966	<u>Venle v. South Central Enterprises, Inc.</u>	Evidence established that a particular herbicide, used by the plaintiff buyer at the defendant seller's recommendation was cause of loss of field of strawberry plants.
<u>Iowa Supreme Court</u>	1966	<u>Niggi v. Laverty Sprayer, Inc.</u>	In action for personal injuries and property damage allegedly resulting from aerial insecticide spraying operations by the defendant the evidence of injuries was insufficient to establish a jury question on the issue of liability. However, there was adequate evidence on the issue of liability of the defendant spraying company for loss of use of the plaintiff's cattle pasture and pond as the alleged result of aerial insecticide spraying.
<u>Court of Appeals, Minnesota</u>	1967	<u>Skogen v. Dow Chemical Co.</u>	Brain damage allegedly caused by exposure of plaintiff to defendant's organo-phosphate insecticide. Judicial review upheld jury finding that brain damage was caused by viral encephalitis rather than organo-phosphate poisoning from insecticide.

TABLE
Continued

Court	Year	Case	Summary
Minnesota Supreme Court	1967	<u>Bates v. Root-Lowell</u> <u>Mfg. Co.</u>	Evidence that consumer held defective insecticide sprayer tube in one hand and glass bottle holding insecticide liquid in other while attempting to assemble the apparatus created question for jury on issue of whether consumer was contributorily negligent or had assumed the risk of the injury resulting from breaking of the insecticide bottle.
Court of Appeals, Illinois	1969	<u>Federal Savings & Loan</u> <u>Insurance Corp. v. Quinn</u>	Condemnation of shipment of spinach due to excessive pesticide levels in the spinach resulted in litigation alleging erroneous determination of contamination. The defendant, a U. S. government employee, claimed sovereign immunity. The appellate court upheld the lower court's decision that the defense of sovereign immunity be waived.

cases.

Analysis of cases presented in Table 3-H and of many more cases from courts of record throughout the country indicate litigation generally involves either negligence of the manufacturer or distributor in conveying the danger of his product, or negligence of the applicator in handling or spreading the pesticide. A third area of negligence involves misuse of pesticides in applications for which they are not intended.

The above cases set several precedents regarding a manufacturer's responsibility to properly warn users of the danger of the product. First, it was determined that a chemical company in compounding, distributing, or applying pesticides is held to the skill of an expert and consequently is charged with superior knowledge of the nature and quality of its products, including their harmful effects (Holladay v. Chicago, B., and Q. Railroad Co.). Further, the manufacturer or compounder of such hazardous materials owes a duty to users to suitably convey notice of this danger, so that proper precautions may be taken to prevent wrongful use and consequent injury. This responsibility is fulfilled by naming and properly communicating the hazards on the label of the package in which the articles are marketed (Land O'Lakes Creameries v. Hungerholt). However, in a case based upon negligence, the plaintiff cannot recover

damages for usage of a product inherently dangerous to human life or health when used as directed or as the manufacturer could reasonably contemplate it would be used, if the manufacturer has given adequate warning of such danger (Hunter v. E. I. duPont & DeNemours & Co.).

Litigation in other states has considered additional areas of the manufacturer's liability in labeling dangerous pesticides. The fact that the manufacturer of a pesticide had complied with the U. S. and Texas acts regulating marketing of pesticides and that the label employed had been approved by appropriate agencies did not preclude a finding of the manufacturer's negligence for failure to warn of the full extent of danger. The manufacturer was guilty of negligence in the case of a child who allegedly died as a result of ingesting a pesticide because the wording of its label gave as an antidote a mere first aid to prevent absorption of the poison by the bodily system but contained no language to indicate that once the poison had been absorbed there was nothing that could be given to counteract its effect (Texas Civil Appeals, 1968, Rumsey v. Freeway Manor Minimax). Even though a poison is known to the ordinary person to be inherently dangerous, there is a common-law duty to warn of the full extent of danger.

In Massachusetts, an appellate court determined that it was a jury question whether the manufacturer of a

120-H

poisonous insecticide should have foreseen that its product would be used by persons of limited education and reading ability and that a warning, even if it were in the precise form of a label submitted to the U. S. Department of Agriculture, would not be adequate, because of its lack of skull and bones or other comparable symbols (Court of Appeals, Massachusetts, 1965, Hubbard-Hall Chemical Co. v. Silverman).

Cases involving pesticide misapplications are generally jury questions of negligence. Horticulturists have the right to use dusts and sprays to protect their growing crops from insects and diseases, but they must exercise due care in doing so, and may be held liable in damages for spreading poison dusts and sprays negligently. Farmers may not delegate the work of dusting or spraying a crop with poisonous pesticides to an independent contractor and thus avoid liability for negligently spreading poisonous dusts and sprays (Mississippi Supreme Court, Lawler v. Skelton).

121-H

Summary and Conclusions

The contractor has endeavored to examine and present in concise form, the status of Federal and state laws directly pertinent to the five-state study area. By collecting and analyzing pertinent laws at the state and Federal level, and through a series of interviews with key people, a picture of good and bad has been assembled; each will be presented with the contractor's evaluation of areas of needed reform.

The Federal regulation of pesticides operates under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), enacted in 1947 and amended in 1959, 1961 and 1964.

The act prohibits the interstate or international shipment of economic poisons unless they: are registered pursuant to provisions of Section 4 of the act, are in unbroken immediate containers, and are labeled according to the provisions of the act.

Should the Administrator find that an imminent hazard to the public would exist, he may suspend the registration of an economic poison immediately.

Any person who violates this law may be found guilty of a misdemeanor and on conviction can be fined not more than \$1,000.00.

New Federal Legislation

During 1971, Congress has considered legislation to amend or replace FIFRA. At least eight different bills dealing with pesticides were introduced in the House of Representatives. The primary one was H. R. 4152. In the Senate four bills have been under consideration, two of which (S. 600 and S. 745) would - like H. R. 4152 - replace the present FIFRA. The other bills would either prohibit the sale of DDT or prohibit the sale of aldrin, chlordane, DDD, TDE, dieldrin, endrin, heptachlor, lindane, and toxaphene. The fate of any legislation in the Congress is to be considered uncertain until enacted by both Houses and sent to the President. H. R. 10729, the Committee rewrite of H. R. 4152, was enacted by the House in the first session of the 92nd Congress. There is strong expectation that Senate action in the 1972 session will result in enactment of a new FIFRA very similar to H. R. 10729.

H. R. 10729 incorporates many of the provisions of the existing law (FIFRA), but goes well beyond it in the Federal regulation of intrastate as well as interstate activities, including registration of pesticides in intrastate commerce. It provides for the classification of pesticides as to: (a) "general use" or (b) "restricted use." The original versions had a third category of

"use by permit only." It also provides for the certification of pesticide applicators. It provides for aid and guidance to states in developing training programs for pesticide applicators and for the certification of individuals entitled to use restricted pesticides.

The bill also substantially increases the enforcement powers of the Federal agency. There are provisions for criminal misdemeanor and for civil penalties. These include not only the registrant, wholesaler, dealer, retailer, or other distributor, the commercial pesticide applicator, but the farmer who knowingly violates any provision of the Act.

Impact of the Pending Federal Legislation

A sampling of views from Congressional offices in the five-study states of Minnesota, Illinois, Iowa, Missouri and Kansas showed: (1) the legislation was an integral part of more effective pollution control, (2) improved control of commercial and private applicators to prevent overdoses and careless applications, (3) more effective handling of pesticides, (4) reduction in on-site storage of pesticides, and (5) more effective control over retail sales subject to recall on order of the Administrator.

There seemed to be a general concurrence from farm communities on the need for legislation of this general nature. The contractor's own survey and Congressional office mail strongly express approval for passage of the legislation. The greatest opposition came from some retailers who were also applicators and some commercial applicators - both saw impending legislation as entirely too restrictive.

With respect to the potential impact of the Federal legislation and state programs, each Congressional office and the farmers and county agents surveyed indicated the State Departments of Agriculture and Agricultural Extension Services would have major responsibility.

Section 20, Research and Monitoring, and Section 23, of H. R. 10729, State Cooperation and Training, are particularly significant advances. The provisions which specifically empower the Administrator to: (1) foster research in biologically integrated alternatives for pest control, (2) formulate a national plan for monitoring, (3) expand public funds to encourage state programs in training of certified pesticide applicators, are viewed by the contractor as necessary and desirable.

Testing and Registration of New Pesticides

Section 3. Registration of pesticides appears to provide for sufficient information to allow the Administra-

Iowa

The Pesticide Act of Iowa is a combined registration (use) and application law. Licensing provisions and enforcement need to be strengthened in Iowa. Financial responsibility for violation is more stringent in Iowa than in Illinois. The institution of a chemical technology review board in Iowa will allow the Secretary of Agriculture to promulgate additional laws and regulations.

Kansas

Stringent financial responsibility marks the Kansas Pesticide Use Law. Kansas is the only study state required to issue regulations regarding storage and safe disposal of pesticides and used containers. Although viewed as something of an intrusion on the state's own pesticide law, when interviewed, all the Congressmen from Kansas indicated support of H. R. 10729.

Minnesota

Minnesota's Spraying and Dusting Law was the first law in the five-state study area to employ restricted use pesticide classification. DDT and its metabolites and the cyclodienes were severely restricted as of July, 1970.

Congressman Bergland did not feel that the farmers of Minnesota have been at any disadvantage to farmers from other states because of the restrictions on the use of certain pesticides. He stated that the contacts he

tor to make adequate judgments regarding new compounds. The provisions which allow a full description of tests performed, § 3(c) (1) (D), and the results thereof to the Administrator as he desires and § 3(c) (1), wherein the Administrator shall publish guidelines specifying the kinds of information required in support of registration, are regarded as particularly important. The further provision that the Administrator shall make public all scientific information relating to the registration of any particular compound is viewed as an absolute necessity and long overdue (§ 23 (c) (2), p. 18, lines 4-9).

Illinois

The State of Illinois has sound laws on record which are consistent with H. R. 10729. The provisions of the existing law are rather weak in regard to licensing of employees of pesticide applicators but compliance with the Administration bill should insure training and safety precautions. When asked about this issue, Congressman Finley's office indicated: (1) response to this bill has been favorable, (2) the bulk of the farmers and farm cooperatives recognize the need to work within a regulatory framework in order to preclude more restrictive limitations on their use of agricultural chemicals, (3) farm cooperatives are gearing up to assist farmers through education to qualify under proposed registration systems.

has had with farmers and farm organizations have at no time indicated such a disadvantage. The general tenor of comments from his home district during the period when the legislation was under consideration was favorable to passage. The only comments he has received since he voted for the bill have been from individuals who expressed the view that legislation along the lines of H. R. 10729 has been long overdue.

In total view, Minnesota already has more stringent control than most states and compares favorably with the Administration bill. No difficulty is seen in field implementation of that legislation.

It should be admitted that Minnesota does not have the same degree of agricultural involvement, as, say, Iowa or Illinois, as far as corn and soybeans are concerned.

Missouri

Missouri has the weakest pesticide control law in the five-state study area. Two bills introduced in 1971 were fought strenuously by dealers and manufacturers. Public hearings were held and testimony received. Manufacturers and applicators reported they could live with the House committee substitute for 315 and 571. Biologists and environmentalists were also satisfied. However, when

brought to a vote, the bill failed to pass and both sides appeared to be surprised. At a special session (November 18, 1971) it was decided that proponents of the bill(s) would wait and see what happened to the Administration bill in the Senate (H. R. 10729).

Identity of Favorable Types of Laws

The results of the contractor's survey of farmers, county agents, Congressional offices, pesticide applicators and retailers, support the Administration bill (H. R. 10729). Although some states presently have laws which appear to control use and application, it is seen that sufficient control is not observed in practice at all times. Hopefully the provisions of the bill, which would strengthen or reinforce Federal aid to educational programs designed to improve methods of application and human safety, would have their impact in increased environmental protection as well.

Some of the verbiage of the existing state laws is rather loose in the interpretation of how to dispose of containers and unused pesticide. Hopefully, this major source of environmental contamination will be solved by more useful state laws in the future. As indicated in another section of this report, many farmers have expressed an earnest desire to dispose of their material in a suitable way but do not know of a practical solution.

Aid in this matter should come from all states as soon as possible.

Assistance to farmers by way of increasing their ability to implement soil erosional control techniques would have the multiple advantage of increasing crop yield, keeping soil loss to a minimum and, most importantly, keeping pesticides used on the land where they are normally effective. An obvious benefit would occur to farmers since annual application of certain compounds could be adjusted downward to take advantage of residue.

The strengthening of applicator laws is viewed as another very desirable feature of some laws. However, responsible operators who perform valuable services should not suffer from over-regulation.

Recommendations

As previously stated, the contractor, throughout surveys and interviews, found general support for the Administration Bill (H. R. 10729). Obvious areas of concern are included in this bill but certain points which will ultimately aid in the implementation of the bill through administrative order should be identified.

Licensing of Products

Licensing provisions of the bill appear adequate provided sufficient valid support of claims is presented. This would include updated standards, especially in the area of chronic sub-lethal exposure, with due regard for the degree of biomagnification identified for members of each trophic level. Rising costs dictate that new products should not be unduly restricted where no imminent harm to humans or, more important, to the total ecosystem is presented. To streamline the procedure, a temporary license could be provided and at this time, or earlier, support monies could be utilized to draw private institutions or respected scientists and universities into the entire process. Through these agencies, sophisticated studies of kinetics of movement through ecosystems and basic physiological responses at different trophic levels could be used to augment the registration procedure. Compounds could be identified by number to protect corporate interests and workers placed under some kind of confidential status. The important point here is that specific items of information could be identified by EPA and updated standards applied so that needless duplication could be avoided and rigorous adherence to standards employed.

Compounds which are known to rapidly hydrolyze or otherwise decompose in the environment should be given considerably more latitude than compounds which are specifically identified as persistent. Due regard for human safety with less persistent, but more toxic compounds is, of course, a requisite.

The contractor feels that the sooner the present persistent compounds are removed, or sharply curtailed in use, the better. It should be indicated here that the present practice of permitting the overseas sale of compounds such as DDT is a direct violation of the trust placed in the hands of scientists and administrators in the United States. The contractor feels very strongly that if we have reason to believe that such persistent pesticides are regarded as too dangerous for domestic use, we have no right, especially in view of our position of world leadership in science, to authorize their sale and use overseas to further contaminate the global environment.

The United States should, in fact, assume a leadership posture of global concern and actively strive to implement international regulation of such compounds.

Prescription Dispensing and Sales

The contractor believes that there are some applications of some persistent pesticides which may be tolerated; structural pest users and other uses which show none, or very little likelihood of environmental contamination, may be considered. In any event, the amounts used should be rigidly controlled and even these uses should be phased out as soon as compounds with more desirable characteristics are found.

Prescription use connotes a cumbersome machinery generally. Hopefully this will not be necessary as state cooperation and implementation of educational plans comes into being. It has been demonstrated that far too many people who use the mere toxic compounds do so in a careless fashion -- apparently unaware of their poisonous nature.

We should strive to achieve integrated methods and control which would specifically identify the need for use of these compounds only when needed and in the amounts needed.

Additional control is obviously required in the use of heavy metal compounds.

Application

These points have been covered elsewhere in this report. It is clear that some kind of licensing is required, if for no other reason, so that each state knows who is doing the application. Federal and state sponsorship of training requisite to licensing is encouraged. These items by themselves still do not insure that proper application techniques will be followed. The threat of license revocation after repeated instances of careless application and the possible forfeiture of bond, or the inability to secure adequate bonding in the future, are seen as necessary and desirable implementation features. Many commercial applicators have a demonstrated record of careful use of pesticide materials. They should find it easy to comply with regulations. Others, less careful, and ignorant of the consequences of their acts, are a potential threat to all and especially the environment. Their services are no longer required or desired.

Safe Disposal

Catalytic thermal decomposition is not possible by the average farm user. Clearly, state or Federal implementation is required to dispose of unused or surplus

pesticides. The biggest single complaint from farmers was that nobody had provided sufficient information for safe disposal. Regional and area wide collection points may be required. Dumping or burying are clearly inadequate at present. Directions such as those on manufacturers' packages, which call for the user washing out the container before incineration, fail to tell him what to do with the washings.

Control and Treatment Techniques

Decontamination from persistent organo-chlorides appears to pose little threat to human health. The same cannot be said for more highly toxic compounds. State-wide implementation, such as that in Kansas and Iowa, which alerts medical doctors to the possibility of harm, is a possible helpful measure. Prescribed safety methods, including the wearing of plastic garments and gloves or respirators, appear to be largely ignored, with the exigencies of planting time. The contractor thus recommends that additional steps be taken by manufacturers to produce formulations which are more dust-free, covered with a protective coating which could dissolve when wetted, or such other plans which would reduce the likelihood of human exposure.

It is recommended that considerably more effort be expended in the area of controlled degradation and self-destruct methodology. Some steps have already been taken but the unfortunate thing is that many of the compounds used to catalyze the destruction may, themselves, reach toxic concentrations with prolonged use. One incentive here could be a premium placed on compounds with demonstrated self-destruct or auto-degradation capabilities at the time of application for registration.

Pesticide Containers

Standardization of leak-proof, safe containers is absolutely called for. The manufacturer who packages in a desirable container and then tells the farmer to destroy it is obviously unaware of the inherent thrift of most farmers. Self-punching boxes and cans which do not require additional handling by the operator have been suggested. The payment of demurrage or a premium on returned containers is also offered.

Additional research is badly needed in methods of adequate disposal of used pesticide containers.

Effluent from Manufacturers and Formulators

This is seen as an area of considerable abuse. It is recommended that stringent effluent requirements be instituted and enforced against manufacturers and formulators. Every day that goes by with kilogram quantities of pesticides entering the aquatic ecosystem is another black day in our history. Whether activated carbon columns are used to treat all effluent water or whether lagoons which utilize biomagnification or accumulation with subsequent expected incineration of the biotic concentrator or whether some other method is used, one fact remains: we have passed the point where we can allow pesticide-laden effluent water to enter our public waterways through municipal sewers and other discharge pipes.

Information Collection and Dissemination

The contractor has stated elsewhere the need and desirability of a more complete information exchange between manufacturers and the rest of the scientific community. Due regard to the interests and degree of financial involvement of the pesticide companies must always be considered. We recommend such integrated research programs (see above) as will streamline the registration procedure, enhance cooperation between

scientists and generally insure that adequate information is gathered openly to assure maximum environmental protection.

• U. S. GOVERNMENT PRINTING OFFICE : 1972 O - 468-258